Three Essays on the Economics of Earnings Management in Capital Markets

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The Chairman of the Doctoral Board: Prof. Dr. Steven Ongena

For my family.

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Contents

Preface

The role of accounting is to provide financial information to the stakeholders of a firm. Investors as capital market participants use the information conveyed in financial reports for firm valuation. By doing so, they evaluate the reports and aim to identify the underlying performance. On the other hand, firm managers are often compensated based on financial statements. This causes adverse incentives to misrepresent accounting numbers which can lead to earnings management.

The presence of earnings management can deteriorate the usefulness of accounting for firm valuation and mitigate the efficiency in capital markets. In my thesis, I analyze earnings management with a focus on three different subjects: reputational concerns, mergers & acquisitions (M&A) and investor sophistication.

Chapter 1 comprises the joint study of Ulrich Schäfer and me which is based on the seminal work of Fischer and Verrecchia (2000). We study managers' reporting bias if the report is not only used by the capital market, but also by the labor market to address the question on how financial incentives and reputational concerns affect capital market efficiency. To this end, we assume that the manager has private information on her incentives. Hence, reporting bias cannot be perfectly backed out from financial reports. Furthermore, firm value is the sum of two components: asset value and managerial talent. While the capital market is interested in total firm value, the labor market assesses only the manager's talent.

Fischer and Verrecchia (2000) show that when financial reports are only processed by the capital market as a single user, increasing uncertainty leads to additional demand for information which improves value relevance and price efficiency. We show that this does not necessarily hold true if multiple stakeholders use the report: If the labor market additionally uses the report for talent assessment, increasing fundamental uncertainty has countervailing effects. Higher uncertainty leads to higher market reactions which in turn increases biasing incentives and therefore reporting noise. Higher uncertainty about managerial talent generally improves labor market efficiency, but the additional reporting noise potentially decreases value relevance and price efficiency in the capital market. This is particularly the case if markets' uncertainty about reporting incentives are sufficiently high and if talent uncertainty is low compared to the overall fundamental uncertainty.

In *Chapter 2*, I study earnings management in an M&A transaction where a target firm is sold to a buyer. Therefore, I examine the consequences of misreporting incentives on reporting bias, value relevance and price efficiency to provide a possible theoretical explanation on empirical evidence for low price efficiency and overpayment in M&A.

I model a two-stage reporting game according to Caskey, Nagar, and Petacchi (2010) with a target manager who reports firm value to an intermediary such as an investment bank or consulting firm hired by the seller. The intermediary tries to remove the manager's bias and reports firm value to the buyer, thereby biasing its own report. The seller pays a success fee to the intermediary that is of particular interest to my analysis because it affects biasing incentives of both, the manager and the intermediary.

I find that the buyer's reaction coefficient on the intermediary report as an indicator for value relevance is always maximized for a success fee of zero. In this case, the intermediary reports his best estimate of firm value. On the other hand, price efficiency can be increasing or decreasing in success fee, depending on the relative uncertainty about biasing incentives of the manager and the intermediary. An increasing success fee has two countervailing effects on price efficiency: The intermediary's biasing incentives are increasing in success fee which reduces price efficiency but then a higher fee simultaneously decreases the manager's incentives to bias, resulting in an increasing price efficiency. However, if there is uncertainty about both players' incentives, price efficiency is always maximized for an interior solution of success fee between zero and one.

In *Chapter 3*, Robert F. Göx and I study the effect of investor sophistication on earnings management. We examine the question on how different investor types affect managerial misreporting and price efficiency. To this end, we extend the linear rational expectations model of Goldstein and Yang (2017) with a reporting game. The manager of a firm issues an accounting report to a capital market where the firm's stock is traded as a risky asset. In addition to informed, uninformed and liquidity traders, we follow Hirshleifer and Teoh (2003) and Hirshleifer, Lim, and Teoh (2011) by introducing limited attention traders as a fourth investor category. Both, informed and uninformed traders attend to stock price and public report while the former additionally observe a private signal about firm value. Limited attention traders exhibit limited information processing capacity and base their stock demand solely on the public report issued by the manager. The demand of liquidity traders is stochastic and based on exogenous reasons.

In line with previous studies, we find that a higher degree of investor sophistication represented by a higher (lower) proportion of informed (limited attention) traders reduces the price response to the accounting report and therefore earnings management incentives. However, a further decline in investor sophistication through a higher fraction of liquidity traders can increase earnings management due to countervailing effects: More liquidity traders in the market imply a lower sensitivity of the aggregate demand for shares to the accounting report and, simultaneously, increase the aggregate valuation risk which reduces the sensitivity of demand to changes of the share price. Since the first effect decreases and the second effect increases earnings management, the overall impact is ambiguous.

Contrary to empirical evidence, we show that price efficiency can be increasing in limited attention: An increase in the fraction of limited attention traders decreases both, the covariance between value and price and the variance of the price. Because price efficiency is negatively affected by a lower covariance but positively affected by a lower price volatility, price efficiency is increasing in limited attention if the latter effect dominates the former.

Overall, our results suggest that a careful definition of investor sophistication is crucial for empirical research in this field.

Chapter 1

Effects of Financial Incentives and Reputational Concerns on Reporting Bias*

Abstract

We study managers' decisions to bias financial reports if these reports are used by capital and labor markets to learn about firm value and managerial talent. If managers have private information on their financial and reputational incentives, we identify interactions in the capital and labor markets' use of reports: The reception of reports in one market motivates reporting bias, which reduces value relevance and price efficiency in the other market. This interaction changes established results and has implications for financial reporting standard setters: We characterize environments where capital market efficiency can be improved by eliminating information on managerial talent from financial reports – even if this information is relevant for investors. This is particularly the case if there is high uncertainty about managers' reputational concerns and if talent uncertainty represents a small part of the overall fundamental uncertainty.

Keywords: reporting bias, reputation, market efficiency, reporting users

* This thesis chapter is based on the unpublished working paper:

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A version of this paper has been submitted to *The Accounting Review* and is under review.

1.1 Introduction

In past decades, several severe cases of earnings management have attracted public attention. They usually were followed by debates on dysfunctional effects of equity-based incentives: Rewarding managers for changes in stock price potentially motivates them to misrepresent the economic situation of the firm, for instance by using their discretion in biasing financial reports (e.g., Burns and Kedia, 2006; Crocker and Slemrod, 2007). The public debate focuses on financial incentives. Yet, there are other reasons for managers to misreport earnings. In a survey of 169 CFOs, Dichev et al. (2013) find that "80.4% believe that senior managers misrepresent earnings to avoid adverse career consequences". This should not be surprising as academic literature on incentive provision emphasizes the role of reputation and career considerations in managerial decision making. Even in the absence of explicit financial incentives, managers try to signal talent to create job opportunities and influence future compensation (e.g., Fama, 1980; Holmström, 1982).

Preparers of financial reports arguably encounter both types of incentives when making their reporting choices. We therefore consider the joint effect of financial incentives and reputational concerns on a manager's decision to bias statutory reports. Financial reports convey information on both firm profitability and the talent of the management in place. They serve the dual purpose of informing investors about firm value and providing information about the management, which can be used by future employers. Thus, managers are tempted to inflate financial reports (i) to mislead the capital market and increase their variable compensation and (ii) to build up reputation in the labor market.

A key assumption in our study is that capital and labor markets face uncertainty about managers financial and reputational incentives.[1] Financial incentives may be unknown because outsiders do not know the details of managers' compensation arrangements and private stock holdings (e.g., Fischer and Verrecchia, 2000). Benefits of managerial reputation are potentially realized in the distant future. Thus, asymmetric information with regard to reputational concerns may result from managers' unknown career plans and

[1] Ferri, Zheng, and Zou (2018) find that investors' earnings response depends on the availability of public information on managers' compensation arrangements. This indicates that uncertainty about managers' financial incentives is relevant in real reporting environments. Moreover, price reactions to voluntary departures indicate that markets are unable to anticipate managers' career-related decisions. A recent example is the 8.4% stock price drop of Netflix, Inc. following the announcement that its CFO David Wells has decided to step down, see Ramachandran and Trentmann (2018).

individual time preferences. If managers' reporting objectives are uncertain, their bias cannot be perfectly backed out from financial reports but is associated with noise.[2]

Given this assumption, we find that financial incentives and reputational concerns have interrelated effects. Capital and labor market efficiency are reduced if the financial report is simultaneously used in both markets to learn about the firm value and managerial talent. To provide intuition for this result, assume that the labor market uses the financial report to update beliefs about managerial talent. This creates incentives for the manager to overstate firm performance. Because financial investors are uncertain about the strength of the manager's reputational motives, they anticipate *that* the manager manipulates the report, however they do not know *how much* bias is added. Thus, information on firm value is diluted and investors curtail the usage of the report to update their beliefs. Following this logic, increasing usage of the financial report in the labor market reduces its usefulness in the capital market and vice versa.

We show that the interactions of financial and reputational incentives challenge previously established results. Existing literature concludes that higher uncertainty about fundamental information improves value relevance and price efficiency. It creates additional demand for information and increases the value of financial reports in reducing uncertainty (Holmström, 1982; Narayanan, 1985; Fischer and Verrecchia, 2000). In our setting, managerial talent represents fundamental information in the labor market *and* in the capital market as it affects firm value. One might therefore expect that higher talent uncertainty improves capital and labor market efficiency. Yet, we identify cases where capital market efficiency decreases in the uncertainty about talent: We show that higher talent uncertainty generally amplifies earnings response in the labor market. This increases incentives to bias the report. The additional reporting noise potentially overcompensates the increased demand for information in the capital market.

Our results have implications for the design of financial reporting standards. A prominent objective of standard setters is to provide information that affects investors' firm valuations. For instance, the IASB Conceptual Framework for Financial Reporting directs firms to report information which is relevant to investors and creditors independent of its relevance to other reporting users. This includes information on managerial contri-

[2] Beyer, Guttman, and Marinovic (2018) find strong evidence for the occurrence and impact of such reporting noise.

bution to firm value (IASB, 2018: OB4 and OB10). We find ambiguous effects of such regulation. Requiring firms to report on managerial talent increases the weight that labor markets assign to reports and aggravates reporting noise. This may reduce value relevance of financial reports in capital markets – even if talent information is relevant to investors. We find that reporting on managerial contribution to firm value may reduce capital market efficiency if (i) there is high uncertainty about managers' reputational concerns and (ii) talent uncertainty represents only a small part of the overall fundamental uncertainty.

On a general level, our results indicate risks in mandating additional information in financial reports, which are not only relevant for financial investors as primary users but also for other stakeholders such as business partners, competitors, rating agencies and the authorities. If such stakeholders increasingly use financial reports as an information source, managers face complex incentives to dissemble, which aggravate the investors' problem to understand and back out reporting bias. Initiatives to increase the informational content of financial reports might therefore backfire and undermine the credibility of reports. This could be one explanation for the mixed empirical evidence of value relevance studies: Although standard setters have extended and refined reporting requirements over the past decades, empirical studies hardly identify an increase of value relevance of accounting information (Francis and Schipper, 1999; Barth, Beaver, and Landsman, 2001; Gu, 2007). Our results show similarities to existing work on relevance-reliability trade offs: Requiring firms to report more extensive information on firm value may have undesirable consequences if the corresponding standards offer managers additional discretion to bias reports. In contrast to this literature, reporting bias in our setting does not result from increased leeway in accounting but from additional reporting users, which are interested in the supplemental information and add incentives to bias financial reports.

Our analysis contributes to three strands of literature. First, our results are related to the literature on *biased financial reporting*. Previous work uses signal-jamming models to study how managers' financial incentives and reputational concerns affect earnings management and market efficiency. The seminal literature assumes that managerial incentives are common knowledge. Stein (1989) studies investment decisions of managers who are interested in maximizing the short-term stock price. Managers choose suboptimal investment levels and inflate current earnings even though this behavior is rationally anticipated by the market. Similar results are obtained if managers have reputational concerns: Holmström (1982) shows that even in the absence of explicit financial incentives managers exert productive effort to manage the labor market's expectations of their unobservable talent. While this outcome might be desirable if firms are unable to provide contractual incentives, Narayanan (1985) illustrates detrimental consequences of reputational concerns. In all these models, earnings management is an equilibrium outcome, but managers fail to deceive the markets. Their decisions are correctly anticipated and do not affect the ability to learn about firm value and managerial talent.

Fischer and Verrecchia (2000) show that this result depends on the assumption that managers' reporting objectives are publicly known. If investors face uncertainty about a manager's equity-based incentives, reporting bias dilutes the informational content of the financial report and reduces the capital market's ability to make inferences on firm value.[3] In this case, higher uncertainty about the manager's incentives reduces capital market efficiency while higher uncertainty about firm fundamentals increases value relevance and price efficiency.[4] We use a similar model framework assuming that firm value partly reflects managerial talent and managers face both financial incentives and reputational concerns. While there is other work addressing the joint effects of financial incentives and reputational concerns (e.g., Prendergast and Stole, 1996; Milbourn, Shockley, and Thakor, 2001), we are the first to consider asymmetric information on both types of incentives. We identify an interaction in the capital and labor market use of financial reports that challenges well-known comparative statics results and allows for novel empirical predictions: Although higher fundamental uncertainty creates additional demand for information, it may reduce earnings response and price efficiency in the capital market.

Second, our study complements the existing literature on *interactions of financial incentives and reputational concerns*. The career concerns literature studies optimal financial incentives in the presence of reputational concerns.[5] In his seminal work, Fama (1980)

[3] Related work uses the assumption of uncertain reporting objectives to study reversal effects of reporting bias (Sankar and Subramanyam, 2001), relevance-reliability trade-offs in accounting (Dye and Sridhar, 2004), the interplay of real and accounting earnings management (Ewert and Wagenhofer, 2005) and implications for firms' voluntary disclosure decisions (Einhorn and Ziv, 2012; Heinle and Verrecchia, 2016).

[4] Uncertainty about managers' reporting objectives does not necessarily result from unknown incentives. For example, Dye and Sridhar (2004) consider unknown costs of misreporting and find similar results.

[5] Career concerns models typically employ a specific set of assumptions: Managers have unobservable ability to increase firm value; all parties hold symmetric ex ante beliefs about managerial ability; future compensation reflects the labor market's beliefs about talent. Our model shares some of these features. However, we do not explicate the formation of compensation contracts and do not require symmetric ex

emphasizes the role of labor markets in disciplining managerial behavior. He delineates a dynamic model framework, in which incentives are provided implicitly by the wage revision process in a competitive labor market. Fama (1980) argues that reputational concerns play a natural role in motivating managers and may be a substitute for explicit financial incentives. Subsequent studies substantiate these results (e.g., Holmström, 1982; Gibbons and Murphy, 1992).[6] For instance, Gibbons and Murphy (1992) show that in the presence of implicit incentives, firms optimize total incentives: If reputational concerns are strong, optimal contracts provide only weak financial incentives. In contrast to this strand of literature, we view financial incentives and reputational concerns from a market perspective rather than a firm perspective: We do not consider optimal contracts in the presence of implicit incentives, but study the joint effect of given financial incentives and reputational concerns on market reactions and market efficiency.

Third, we contribute to the literature studying the *effects of managers' reputational motives on capital market efficiency*. Nagar (1999) addresses firms' decisions on voluntary disclosure if managers maximize the market assessment of their talent. If there is uncertainty about the publicly available information and the corresponding market valuation, (risk-averse) managers might strategically withhold private information. In line with our results, reputational concerns have detrimental effects on price efficiency. Beyer and Dye (2012) consider managers' decisions on disclosing (unfavorable) financial forecasts when their information endowment is unknown. They find that even strategic managers might disclose unfavorable information in early periods to increase the credibility of future nondisclosure decisions. In contrast to our study, they do not address managers' reputation to increase firm value, but their reputation to be forthcoming, i.e., to disclose all available information. While we study a mandatory reporting setting, both Nagar (1999) and Beyer and Dye (2012) consider decisions on (verifiable) voluntary disclosure.

The rest of this paper is organized as follows: In Section 1.2, we explain our model and characterize the reporting equilibrium. The benchmark analysis is presented in Section 1.3. Section 1.4 provides our main results with regard to market efficiency and reporting bias. In Section 1.5, we discuss implications for reporting standard design. Section 1.6

ante information. We therefore refer more generally to reputational concerns instead of career concerns.

[6] Other literature deals with optimal job design (Kaarbøe and Olsen, 2006; Casas-Arce and Hejeebu, 2012), the reporting environment (Autrey, Dikolli, and Newman, 2007) and performance measure aggregation (Autrey, Dikolli, and Newman, 2010; Arya and Mittendorf, 2011).

considers two model extensions to illustrate the effects of correlated fundamentals and multiple reporting users. In Section 1.7, we summarize the results and conclude.

1.2 Model setup

The manager of a publicly traded firm privately observes information about the firm value and releases a (potentially biased) financial report. This report is used by the capital and labor markets to update their beliefs about the firm fundamentals.[7] Before receiving information, the manager shares the market participants' ex ante beliefs about the structure and distribution of firm value. We assume that firm value is the sum of two normally distributed components:

$$\tilde{v} = \tilde{\eta} + \tilde{\theta}. \tag{1}$$

The component $\tilde{\eta} \sim N(0, \sigma_\eta^2)$ represents all aspects of firm value which are not related to the manager in place. It comprises the value created by all tangible and intangible assets independent of managerial influence. We refer to this component as the *asset value* of the firm. The component $\tilde{\theta} \sim N(0, \sigma_\theta^2)$ is the managerial contribution to firm value and epitomizes the *talent* of the manager in place.[8] In our main analysis, we assume that the asset value and managerial talent are stochastically independent, i.e., $Cov[\tilde{\eta}, \tilde{\theta}] = 0$.[9] Thus, the firm value $\tilde{v}$ is normally distributed with mean 0 and variance $\sigma_v^2 = \sigma_\eta^2 + \sigma_\theta^2$.
The manager receives a private signal revealing both the asset value η and talent component θ of firm value.[10] For instance, this signal might represent internal information

[7] Real reporting environments are characterized by multiple stakeholders interested in various aspects of firm value and thus providing incentives to manipulate the information content. In Section 1.6, we show that our main results carry over to a setting with more than two reporting users.

[8] Expected asset value and talent do not affect our results qualitatively and are normalized to zero.

[9] This assumption excludes potential interactive effects of the asset value and managerial talent – a typical simplification in the literature (e.g., Holmström, 1982; Gibbons and Murphy, 1992; Nagar, 1999). However, we acknowledge that complementarities in firms' production functions are likely to exist: More profitable firms hire talented managers and, in turn, these managers increase the profitability of the available resources (see Murphy and Zábojník, 2004; Gabaix and Landier, 2008; Terviö, 2008). In Section 1.6 we allow for positive correlation of $\tilde{\eta}$ and $\tilde{\theta}$ to study the additional effects of such complementarities.

[10] The results of our main analysis do not depend on whether the manager receives disaggregate information on both components or only on aggregate firm value. It seems realistic to assume that an experienced manager holds private information on her talent. Thus, an additional signal of aggregate firm value allows her to make inferences on the realized asset value.

provided by the firm's accounting system which are not publicly observable.[11] Subsequently, the manager must issue a public financial report on firm value. We assume that she can engage in (accounting) earnings management, that is she can overstate or understate firm value in her report r by adding a positive or negative bias $b = r - v$. Misreporting is accompanied by convex private costs:[12]

$$c(r) = \frac{1}{2} \cdot (r - v)^2 = \frac{1}{2} \cdot b^2. \tag{2}$$

Such costs result from the time-consuming process of finding and using leeway in financial reporting standards as well as conflicts with auditors and potential legal liabilities if earnings management is detected.

The capital and labor markets cannot observe any other information about the firm value or its components, but form their beliefs based on the financial report. While there may be alternative ways for managers to signal talent, financial reports are particularly useful for this purpose. They reflect the manager's performance in a real business environment. Furthermore, audited financial reports are arguably more credible than most other information channels. We view capital and labor markets as symmetric and risk-neutral institutions, which efficiently process the available information. They differ only in the fundamental value evaluated. The capital market price P reflects all available information on firm value $\tilde{v} = \tilde{\eta} + \tilde{\theta}$[13] and the talent assessment T in the labor market represents public

[11] We assume that the accounting signal perfectly reveals firm value. Allowing for noisy accounting measurement does not affect our results qualitatively.

[12] Many earnings management studies advance the view that misreporting may be accompanied by considerable costs for managers (e.g., Fischer and Verrecchia, 2000; Dye and Sridhar, 2004). This assumption is reasonable in our setting of mandatory disclosure where the content of financial reports is regulated by standard setters and firms are subject to legal enforcement. We therefore do not consider a cheap talk setting (see Crawford and Sobel, 1982; Stocken, 2000; Bertomeu and Marinovic, 2016). For an overview of disclosure models with both costless and costly signaling see Stocken (2013).

[13] There is empirical evidence that capital market prices incorporate managerial contributions to firm value. For instance, Johnson et al. (1985) and Jenter, Matveyev, and Roth (2016) document abnormal stock price reactions in cases of sudden executive deaths. Nam, J. Ronen, and T. Ronen (2018) show that information on managerial decisions at previous employers affects the current employer's stock price.

information on the manager's talent $\tilde{\theta}$ as one component of firm value:[14]

$$P = E\left[\tilde{v}|r\right] \quad \text{and} \quad T = E[\tilde{\theta}|r]. \tag{3}$$

We assume that the manager's utility U depends on both the market price P as well as the assessment T of her talent. The marginal increase of her utility in the market outcomes is given by the incentive weights x_P and x_T respectively:

$$U = x_P \cdot P + x_T \cdot T - c(r). \tag{4}$$

We do not endogenize incentives but view x_P and x_T as summation of the manager's given explicit and implicit interest in the market outcomes.[15] She privately knows the weights x_P and x_T while the capital and labor markets are uncertain about their realizations.[16]

The incentive weight x_P represents the manager's aggregate financial incentives in the firm's market price. This includes incentives to increase the market price like equity-based compensation, but also implicit incentives to decrease the price, for instance in the case of share repurchases. The incentive weight x_T reflects the manager's reputational incentives: By signaling talent to the labor market, the manager gains reputation. Such reputation is typically related to job opportunities and higher future compensation levels (e.g., Holmström, 1982). Managers differ in their exposure x_T to the talent assessment. For instance, prior studies argue that particularly young managers benefit from high talent assessment and show strong reputational concerns (e.g., Prendergast and Stole, 1996).

[14] This assumption is typical for career concern models. In contrast, Murphy and Zábojník (2004), Murphy and Zábojník (2007) and Eisfeldt and Kuhnen (2013) suggest that there are firm-specific and general talent components where only the latter are transferable between firms. Our results hold qualitatively if we assume that talent θ is the weighted sum of firm-specific and general talent.

[15] For an analysis of optimal incentives when managers provide productive effort and manipulate earnings see Goldman and Slezak (2006), Dutta and Fan (2014) and Peng and Röell (2014).

[16] We follow existing work and use a static reduced-form model to study the effects of misreporting (e.g., Fischer and Verrecchia, 2000; Dye and Sridhar, 2004; Heinle and Verrecchia, 2016). The incentive weights x_P and x_T render the net incentives to bias reports considering all future consequences of misreporting. We do not explicitly model bias reversals under clean surplus accounting nor do we delineate a (dynamic) contracting framework that implies the utility (4). In this regard, we deviate from career concerns models and borrow from disclosure models, which do not provide microstructure of reporting incentives (e.g., Nagar, 1999). The assumption that managers maximize the market price of their talent is not farfetched and could result from the fact that expected talent determines future wages (Holmström, 1982). Then, the incentive weight x_T could reflect the manager's negotiation power (Meyer and Vickers, 1997) or be a "proxy for the length of the agent's career horizon" (Autrey, Dikolli, and Newman, 2010).

Following this argument, x_T may reflect the manager's age. Moreover, note that x_T represents the evaluation of *future* wages. There may be considerable differences in the individual discounting of future compensation (see Holmström and Costa, 1986; Reichelstein, 1997). This could be a result of the individuals' time preferences or career planning. Managers might face high private costs of changing affiliations or are reluctant to change jobs because of attractive internal career opportunities and retention incentives. For this type of manager, talent assessment is less relevant. Negative values of x_T are characteristic of managers who fear the additional responsibility and higher expectations associated with positive talent assessments.[17]

We assume that the capital and labor markets have common beliefs about the distribution of incentives, $\tilde{x}_P \sim N(\mu_P, \sigma_P^2)$ and $\tilde{x}_T \sim N(\mu_T, \sigma_T^2)$ with $\mu_P, \mu_T \geq 0$.[18] It is reasonable to assume that the manager's incentives are not observable by the markets. This is obvious in the case of financial incentives if compensation contracts, bonus arrangements or the manager's private stock holdings are not fully disclosed. While managerial age as one determinant of reputational concerns is observable, there are other determinants, which can hardly be assessed by the market. For example, firms use incentives to retain managers: In many cases, managers suffer considerable losses in deferred compensation, pension claims or other perks like specific loan conditions if they retire. Such contractual clauses are not necessarily public and affect the power of managers' reputational concerns. Moreover, potential benefits of reputation are realized somewhere in the future. Their impact on managers' decisions depends on career plans and individual preferences (for instance, career horizons and time preferences), which are unobservable for firm outsiders.

We analyze perfect Bayesian equilibria of this reporting game characterized by

(i) the manager's reporting strategy $r(\eta, \theta, x_P, x_T)$, which maximizes her utility (4) for given asset value and talent realizations η and θ as well as incentive weights x_P and x_T and conjectures $\hat{P}(r)$ and $\hat{T}(r)$ about the markets' reactions to her report,

(ii) the capital and labor market prices $P(r)$ and $T(r)$ as functions of the financial report r according to (3) for given conjecture $\hat{r}(\eta, \theta, x_P, x_T)$ about the manager's strategy,

[17] Note that our results do not hinge on the fact that x_T may be negative. Our results hold even if the probability of negative x_T is arbitrarily small.

[18] We study a manager's reputation to increase firm value if there is uncertainty about her talent. Instead, we could assume that the manager has private information on her costs of misreporting (see Dye and Sridhar, 2004) and cares for her reputation to report truthfully. Both types of reputation imply similar results.

(iii) the condition that all conjectures are self-fulfilling, i.e., $\hat{r}(\cdot) = r(\cdot)$, $\hat{P}(\cdot) = P(\cdot)$ and $\hat{T}(\cdot) = T(\cdot)$.

As typical in the accounting literature, we restrict our analysis to linear equilibria, i.e., the manager's reporting strategy $r(\cdot)$ as well as the capital and labor market outcomes $P(\cdot)$ and $T(\cdot)$ are linear functions of the available information.[19][20] In line with previous work, we use two measures of market efficiency to evaluate reporting equilibria (e.g., Fischer and Verrecchia, 2000; Ewert and Wagenhofer, 2005; Heinle and Verrecchia, 2016). First, we study the earnings response coefficients (ERCs)

$$\beta_P \equiv dP/dr \text{ and } \beta_T \equiv dT/dr \tag{5}$$

in the capital and labor markets. These measures reflect the sensitivity of the market outcomes to the firm's accounting information. They have been used in the theoretical literature as proxies of *value relevance*. Second, we analyze the relative reduction of uncertainty about fundamentals in the markets:[21]

$$\Pi_P \equiv \frac{Var[\tilde{v}] - Var[\tilde{v}|P]}{Var[\tilde{v}]} \text{ and } \Pi_T \equiv \frac{Var[\tilde{\theta}] - Var[\tilde{\theta}|T]}{Var[\tilde{\theta}]}. \tag{6}$$

The terms Π_P and Π_T measure the extent to which all public and private information about fundamentals is incorporated into market prices. We follow the literature in interpreting theses measures as proxies for *price efficiency* in the capital and labor markets.[22]

Proposition 1 proves the existence and uniqueness of a linear equilibrium.[23]

[19] The restriction to linear strategies allows us to focus on a single equilibrium. Einhorn and Ziv (2012) show that this restriction is useful to rule out unreasonable out-of-equilibrium beliefs.

[20] See Guttman, Kadan, and Kandel (2006) for a more general equilibrium analysis in a model with only financial incentives. The study characterizes equilibria with partial pooling. Even if there is no uncertainty about managers' reporting objectives, investors are no longer able to back out reporting bias.

[21] Market efficiency has been extensively studied in capital market settings, but is typically not considered in labor market models. Studies of reputational concerns typically assume that there is no uncertainty about the value of reputation for managers. In consequence, reporting bias is anticipated and can be backed out from the report. In our setting of uncertain reputational incentives, labor market efficiency is a valid question because bias is accompanied by reporting noise.

[22] Other measures of market efficiency comprise entropy measures (Huang, 2016; Jiang and Yang, 2017) or the (negative) expected squared difference between reported and true value (Fischer and Stocken, 2004). In our model setting, all three alternative definitions coincide.

[23] Proposition 1 characterizes the equilibrium ERCs implicitly. We refrain from stating the explicit solutions as they do not provide additional insights.

Proposition 1 *If the manager is motivated by financial incentives and reputational concerns, there exists a unique linear equilibrium with the following properties:*[24]

$$r = v + b = v + \beta_P \cdot x_P + \beta_T \cdot x_T, \tag{7}$$

$$\beta_P = \frac{\sigma_v^2}{\sigma_v^2 + \sigma_P^2 \cdot \beta_P^2 + \sigma_T^2 \cdot \beta_T^2} \;\; \textit{and} \;\; \beta_T = \frac{\sigma_\theta^2}{\sigma_v^2 + \sigma_P^2 \cdot \beta_P^2 + \sigma_T^2 \cdot \beta_T^2}. \tag{8}$$

The equilibrium strategies have a very intuitive interpretation. The manager chooses the bias level considering both her financial *and* reputational motives. The equilibrium bias level b trades off the marginal benefits and costs of dissembling. The former depend on the markets' responsiveness to the financial report: If it is easier to influence the markets, (i.e., for higher levels of β_P and β_T), the manager chooses a higher bias level. The capital and labor markets' equilibrium ERCs reflect the reported information on firm value and talent respectively, $\beta_P = Cov[\tilde{v}, \tilde{r}] \cdot Var[\tilde{r}]^{-1}$ and $\beta_T = Cov[\tilde{\theta}, \tilde{r}] \cdot Var[\tilde{r}]^{-1}$.

The equilibrium results are useful to determine the measures of market efficiency. It turns out that value relevance and price efficiency are identical measures: The degree to which rational markets rely on the financial report corresponds to its usefulness in reducing uncertainty about fundamentals.[25] Based on this observation, we focus on the analysis of the market ERCs knowing that they represent both value relevance and price efficiency.

Corollary 1 *In equilibrium, the measures of price efficiency and value relevance coincide, i.e.,* $\Pi_P = \beta_P$ *and* $\Pi_T = \beta_T$.

1.3 Benchmark analysis

Previous literature focuses on settings, in which managers' reports are either motivated exclusively by financial incentives ($x_T = 0$, i.e., $\mu_T = \sigma_T^2 = 0$) or by reputational motives ($x_P = 0$, i.e., $\mu_P = \sigma_P^2 = 0$). Lemma 1 summarizes comparative static results in these special cases of our model.[26]

[24] All proofs are provided in the appendix.

[25] The congruence of value relevance and price efficiency does not necessarily hold in a multi-stage reporting environment as considered by Caskey, Nagar, and Petacchi (2010).

[26] Let $\beta_P^B = \beta_P|_{x_T=0}$ and $\beta_T^B = \beta_T|_{x_P=0}$ denote the capital and labor market ERCs in the benchmark cases.

Lemma 1 *Results with either financial incentives or reputational concerns:*

a) *Consider the case that the manager only pursues financial objectives ($x_T = 0$). Higher uncertainty about the firm value (i.e., asset value $\tilde{\eta}$ or talent $\tilde{\theta}$) improves earnings response β_P^B in the capital market.*

b) *If the manager is motivated by reputational objectives only ($x_P = 0$), higher uncertainty about her talent $\tilde{\theta}$ improves earnings response in the labor market. In contrast, higher uncertainty about the asset value $\tilde{\eta}$ reduces the labor market response β_T^B.*

If the manager is not motivated by reputational concerns but seeks to maximize the firm's market price, higher uncertainty about asset value or managerial talent generally improves capital market efficiency. As there is more demand for information, financial reports become more valuable and are used increasingly by investors, i.e., the ERC in the capital market increases ($d\beta_P^B/d\sigma_k^2 > 0$ for $k \in \{\eta, \theta\}$).[27] These effects occur whenever investors use (biased) financial reports to learn about firm value (e.g., Holthausen and Verrecchia, 1988; Stein, 1989; Fischer and Verrecchia, 2000).[28]

In the absence of financial incentives, the manager's reputational concerns have similar effects. Higher uncertainty about her talent makes financial reports more useful for potential employers. Thus, the labor market ERC increases, $d\beta_T^B/d\sigma_\theta^2 > 0$. While talent θ is fundamental information for both markets, the asset value η represents noise for the labor market. It dilutes the talent information without having any explanatory value. In consequence, higher uncertainty about the asset value attenuates the labor market response, $d\beta_T^B/d\sigma_\eta^2 < 0$. These observations are in line with the results of the literature on reputational concerns (Narayanan, 1985; Holmström, 1982; Gibbons and Murphy, 1992).

The generalization of Lemma 1 seems obvious. If fundamental information is associated with higher uncertainty, there is a stronger response to the financial report in the respective market. Although this motivates additional reporting bias, market efficiency is effectively improved. Our main analysis shows that this logic no longer applies if the manager faces both types of incentives.

[27] Note that in equilibrium improved capital market efficiency is associated with higher expected reporting bias, i.e., $dE[\tilde{b}]/d\sigma_k^2 > 0$. This illustrates that measures of reporting bias are inappropriate to evaluate the level of information asymmetry between management and the capital market: Reporting bias is rationally anticipated by the markets, which discount reports for expected bias levels (e.g., Narayanan, 1985; Stein, 1989; Fischer and Verrecchia, 2000).

[28] Note that the uncertainty about the manager's incentives is irrelevant for these results. The logic applies even if her motives are publicly known.

1.4 Main results

Equilibrium analysis

Corollary 2 summarizes characteristics of the reporting equilibrium.

Corollary 2 *Characteristics of the equilibrium ERCs:*

a) The capital market response to the financial report is always stronger than the labor market response, $\beta_T = \sigma_\theta^2 \cdot (\sigma_\eta^2 + \sigma_\theta^2)^{-1} \cdot \beta_P$.

b) The ERCs in the capital and labor market are positive and bounded from above, $0 < \beta_P < 1$ *and* $0 < \beta_T < \sigma_\theta^2 \cdot (\sigma_\eta^2 + \sigma_\theta^2)^{-1}$.

The capital market price is more sensitive to the manager's report than the talent assessment. This results from the nested structure of firm value and managerial talent. The financial report is a noisy signal of firm value, which is the sum of asset value and talent. In contrast to the capital market, the labor market is only interested in the talent component: Potential employers perceive the information on the firm's asset value as additional noise because this information is unrelated to managerial talent. Hence, financial reports show a higher correlation with the total firm value than with managerial talent as one of its components ($Cov[\tilde{\theta}, \tilde{r}] < Cov[\tilde{v}, \tilde{r}]$).

Note that in the presence of uncertain reporting objectives more reporting bias is associated with additional noise. If earnings response increases, the markets rationally anticipate *that* the manager adjusts her bias level. However, they do not know precisely *how much* bias is added due to the uncertainty about the manager's incentives $\tilde{x}_P$ and $\tilde{x}_T$. Formally, the uncertainty associated with the report increases in β_P and β_T:

$$Var[\tilde{r}] = Var[\tilde{v}] + Var[\tilde{b}] = \sigma_v^2 + \sigma_P^2 \cdot \beta_P^2 + \sigma_T^2 \cdot \beta_T^2. \tag{9}$$

This leads to our first main observation. With financial and reputational incentives, both market reactions motivate bias and induce reporting noise. Note that the noise induced by one of the markets represents an information externality for the other market: If the capital market's reaction dilutes the content of the report, the labor market learns less and reduces its response accordingly. Vice versa, the noise induced by the labor market represents an externality for the capital market and is considered by the firm's investors.

As a consequence, the equilibrium capital and labor market ERCs are reduced compared to the benchmark cases with only one type of incentives.

Proposition 2 *The capital and labor market ERCs are lower than in a reporting environment with only financial or reputational concerns, i.e.,* $\beta_P < \beta_P^B$ *and* $\beta_T < \beta_T^B$.

Based on this result, we study comparative static results to gain further insights into the interaction of financial incentives and reputational concerns. Lemma 2 summarizes the effect of higher uncertainty about the manager's financial and reputational motives.

Lemma 2 *Both markets' equilibrium ERCs as well as the expected equilibrium bias are decreasing in uncertainty about the manager's financial and reputational motives,* $d\beta_m/d\sigma_n^2 < 0$ *and* $dE[\tilde{b}]/d\sigma_n^2 < 0$ *for* $m, n \in \{P, T\}$.

Higher uncertainty about the manager's financial incentives or her reputational concerns aggravates the noise in the report and attenuates the markets' equilibrium reactions. As a consequence, the manager faces lower-powered incentives to bias the report. This result is standard in the literature (e.g., Fischer and Verrecchia, 2000) and also holds in our model with financial and reputational incentives.[29]

Next, we study the effect of higher uncertainty about firm value on the equilibrium results. The results in this case are less obvious and require a detailed analysis. The equilibrium ERCs according to Proposition 1 formalize the interdependency between financial incentives and reputational concerns: The ERC β_P in the capital market is a function of the model parameters as well as the ERC β_T in the labor market and vice versa.

Corollary 3 *Increasing uncertainty* σ_η^2 *and* σ_θ^2 *about the value components has a direct as well as an indirect effect on each equilibrium ERC:*

$$\frac{d\beta_P}{d\sigma_k^2} = \underbrace{\frac{\partial\beta_P}{\partial\sigma_k^2}}_{\equiv D_{P,k}} + \underbrace{\frac{d\beta_P}{d\beta_T}\cdot\frac{d\beta_T}{d\sigma_k^2}}_{\equiv I_{P,k}}, \quad \frac{d\beta_T}{d\sigma_k^2} = \underbrace{\frac{\partial\beta_T}{\partial\sigma_k^2}}_{\equiv D_{T,k}} + \underbrace{\frac{d\beta_T}{d\beta_P}\cdot\frac{d\beta_P}{d\sigma_k^2}}_{\equiv I_{T,k}} \quad \text{for } k \in \{\eta, \theta\}. \tag{10}$$

$D_{m,k}$ *and* $I_{m,k}$ *measure the direct and indirect effects of increasing* σ_k^2 *on* β_m, $m \in \{P, T\}$.

[29] Although not explicitly stated, this result also prevails in the benchmark cases of section 1.3.

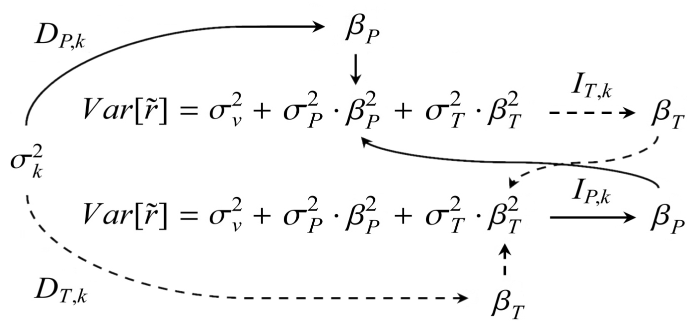

Figure 1 *Direct and indirect effects of higher uncertainty about firm value ($k \in \{\eta, \theta\}$)*

Figure 1 illustrates the direct and indirect effects identified in Corollary 3. If the uncertainty σ_k^2 about the asset value ($k = \eta$) or managerial talent ($k = \theta$) increases, this has direct impact on both equilibrium ERCs according to (8). The direct effects reflect the optimal earnings response in one market holding the other market's response fixed.

The indirect effects are a consequence of the manager's reaction to the direct effects. Higher uncertainty about the firm value implies an adjustment of the markets' ERCs β_P and β_T. As illustrated in (9), the adjustment of the capital market ERC β_P also affects the reporting noise and thus creates an externality on the usefulness of the report in the labor market. Vice versa, the direct effect on β_T alters the investors' ability to learn about firm value. These externalities create the indirect effects formally defined in Corollary 3.

Following the argument above, the indirect effect $I_{m,k}$ of higher uncertainty about the value component $k \in \{\eta, \theta\}$ on the ERC β_m aggregates two effects formally given by the derivatives $d\beta_m/d\beta_n$ and $d\beta_n/d\sigma_k^2$. First, the other market's ERC β_n influences the reporting noise and thereby the equilibrium level of β_m.[30] Second, the other market adjusts its reaction to higher uncertainty about the value component. If managers are motivated exclusively by financial incentives ($x_T = 0$), the ERC in the capital market fully reflects the direct effects, i.e., $I_{P,\eta} = I_{P,\theta} = 0$. Analogously, if managers are motivated by reputational concerns only ($x_P = 0$), the reaction of the labor market is independent of the capital market response, i.e., $I_{T,\eta} = I_{T,\theta} = 0$.

[30] This requires that the incentive weight related to the outcome of the other market is uncertain, $\sigma_n^2 > 0$. It is obvious from (8) that $d\beta_m/d\beta_n \leq 0$. Equality only holds for $\sigma_n^2 = 0$.

The effect of higher uncertainty about the asset value

This section provides a detailed analysis of the direct and indirect effects of increasing uncertainty about the asset value. Lemma 3 establishes the signs of these effects.

Lemma 3 *Direct and indirect effects of higher uncertainty about the asset value:*

a) Higher uncertainty about the asset value σ_η^2 has a positive direct effect on earnings response in the capital market ($D_{P,\eta} > 0$), but a negative direct effect on the labor market reaction ($D_{T,\eta} < 0$).

b) The indirect effects that are associated with an increase of the uncertainty about the firm's asset value σ_η^2 amplify the direct effects, i.e., $I_{P,\eta} > 0$ and $I_{T,\eta} < 0$.

The asset value $\tilde{\eta}$ represents fundamental information for investors, but noise in the labor market. Thus, higher uncertainty about this component provokes a positive direct effect in the capital market: There is more to learn for investors who show greater responsiveness to the report, i.e., $D_{P,\eta} > 0$. At the same time, information about the manager's talent is diluted and the labor market's reaction to the report is attenuated, i.e., $D_{T,\eta} < 0$.

The indirect effects of σ_η^2 amplify the direct effects. Increases in σ_η^2 attenuate the labor market's earnings response and thus reduce the manager's incentives to dissemble. The noise in the financial report is reduced, which, in turn, enhances its usefulness for the financial investors, $I_{P,\eta} > 0$. Moreover, the positive direct effect in the capital market motivates additional bias. According to (9), this dilutes information about managerial talent and makes the report less useful for the labor market, $I_{T,\eta} < 0$. The total effects are unambiguous because direct and indirect effects are equally directed.

Proposition 3 *If the uncertainty σ_η^2 about the asset value increases, the capital market's earnings response β_P increases while the labor market's earnings response β_T decreases.*

Our results confirm the expectations raised in the benchmark analysis. The asset value η is relevant information in the capital market. Hence, higher uncertainty σ_η^2 makes the financial report more valuable for investors of the firm. The corresponding ERC increases, $d\beta_P/d\sigma_\eta^2 > 0$. At the same time, η is unrelated to the manager's influence on firm value and dilutes the talent information in the report. The labor market therefore reduces its ERC in response to higher uncertainty about the asset value, $d\beta_T/d\sigma_\eta^2 < 0$. As the direct and indirect effects have the same sign, there is no ambiguity in the market reactions.

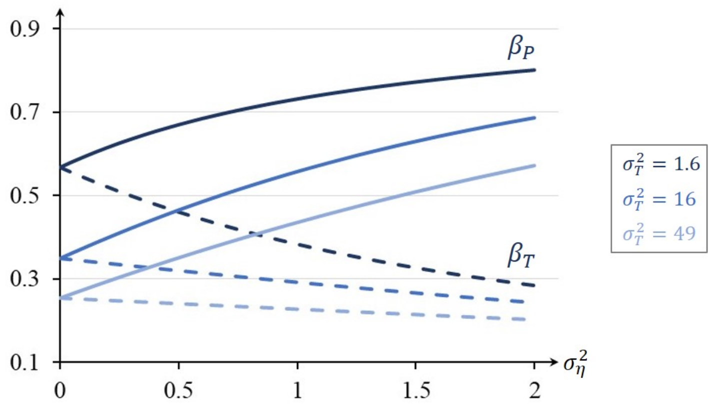

Figure 2 *Effects of higher uncertainty about the asset value on market efficiency* ($\mu_P = \mu_T = 40$, $\sigma_\theta^2 = 1.1$, $\sigma_P^2 = 1$)

Figure 2 illustrates our results. The three graphs depict the equilibrium ERCs for different degrees of uncertainty about the manager's reputational concerns, $\sigma_T^2 \in \{1.6, 16, 49\}$. As shown in Lemma 2, both earnings reactions are unambiguously decreasing in the variance σ_T^2: The markets learn less about firm fundamentals if there is more uncertainty about the manager's motives. As a consequence, the manager's incentives to dissemble are attenuated. Confirming Proposition 3, the capital market ERC β_P is increasing and the labor market ERC β_T is decreasing in higher uncertainty about the asset value.

The effect of higher uncertainty about talent value

In this section, we turn to the effects of higher uncertainty about the managerial talent. Lemma 4 characterizes the direct and indirect effects of talent uncertainty.

Lemma 4 *Direct and indirect effects of higher talent uncertainty:*

a) Higher uncertainty σ_θ^2 about managerial talent implies a positive direct effect on both market reactions, i.e., $D_{P,\theta}, D_{T,\theta} > 0$.

b) The sign of the indirect effect of higher talent uncertainty σ_θ^2 on the capital market response is negative ($I_{P,\theta} < 0$). The indirect effect $I_{T,\theta}$ on the labor market response is ambiguous.

In contrast to the asset value, managerial talent θ represents fundamental information for capital *and* labor markets: The labor market is inherently interested in the manager's talent; financial investors learn about its contribution to firm value. Thus, increasing the uncertainty about talent makes the financial report more valuable for both reporting users. This is reflected in positive direct effects, $D_{P,\theta}$, $D_{T,\theta} > 0$.

Interestingly, the indirect effects of higher talent uncertainty can be opposed to the direct effects. The positive direct effects on both markets' ERCs provide additional incentives for the manager to bias the report and thus introduce additional noise as illustrated in equation (9). This creates a counterforce to the direct effects. The indirect effects subsume these countervailing effects: While the indirect effect on the capital market response is generally opposed to the direct effect ($I_{P,\theta} < 0$), the sign of the indirect effect $I_{T,\theta}$ on the labor market ERC is ambiguous. It can amplify or counteract the direct effect.

The reason for the asymmetry in the results is the nested structure of the fundamental information in the market objectives. Financial investors assign a market price based on both asset value and managerial talent; the labor market assesses only talent as a subset of these components. In line with Corollary 2 a), this implies that the equilibrium ERC in the labor market is always lower than the equilibrium ERC in the capital market. At the same time, β_T is more sensitive to changes in the variance σ_θ^2.[31] To formalize this argument consider the indirect effects according to Corollary 3. $I_{P,\theta}$ and $I_{T,\theta}$ reflect the total variations $d\beta_T/d\sigma_\theta^2$ and $d\beta_P/d\sigma_\theta^2$ of the equilibrium ERCs. It is easy to see that the marginal increase of the labor market ERC in talent uncertainty generally exceeds the increase of the capital market ERC, $d\beta_T/d\sigma_\theta^2 > d\beta_P/d\sigma_\theta^2$. While the former is always positive, the latter can take negative values. As a consequence, the capital market response is strictly attenuated while the indirect effect on the labor market response is ambiguous. Proposition 4 summarizes the total effects of higher talent uncertainty.

Proposition 4 *The labor market's earnings response β_T increases in the uncertainty about the manager's talent σ_θ^2. The effect of talent uncertainty on the capital market's earnings response β_P is ambiguous.*

Managerial talent θ represents fundamental information in both markets. Following the arguments of the benchmark analysis, higher talent uncertainty should therefore increase the demand for information and enhance the usefulness of the report for both reporting

[31] This is apparent from the implicit characterization in (8).

users. Proposition 4 only partly confirms this intuition. Indeed, the labor market's earnings response increases in talent uncertainty. However, higher uncertainty about the manager's contribution to firm value can reduce earnings response in the capital market. The reason for this observation is the interdependency between the markets' ERCs resulting from the manager's incentives to dissemble. Proposition 5 provides a detailed analysis of the ambiguous effects of talent uncertainty on the capital market ERC.

Proposition 5 *The ambiguous effects of talent uncertainty on the capital market ERC:*

a) *If the uncertainty about the manager's reputational concerns is sufficiently high compared to the uncertainty about her financial incentives ($\sigma_T^2 > 3 \cdot \sigma_P^2$), the capital market's earnings response is decreasing in intermediate values of talent uncertainty $\sigma_\theta^2 \in [\underline{\sigma}_\theta^2, \bar{\sigma}_\theta^2]$ and increasing elsewhere.*

b) *The range $[\underline{\sigma}_\theta^2, \bar{\sigma}_\theta^2]$ is widened as the uncertainty about the manager's financial motives decreases or the uncertainty about her reputational concerns increases. It is bounded by the uncertainty about the asset value, $[\underline{\sigma}_\theta^2, \bar{\sigma}_\theta^2] \subset [0, 2 \cdot \sigma_\eta^2]$.*

Whether the capital market ERC is decreasing in the variance of talent depends on the relative uncertainty about the manager's financial and reputational motives. These results reflect our previous observations. As the uncertainty about financial incentives decreases, the externality of the financial investors' reaction on the labor market ERC β_T is attenuated. Thus, the labor market response provides high-powered incentives to bias the financial report. This again introduces noise into the report, especially if there is high uncertainty about the manager's reputational concerns. The report becomes less useful for investors. As a consequence, low values of σ_P^2 and high values of σ_T^2 characterize settings, in which the capital market ERC is decreasing in talent uncertainty.

Our results are illustrated in Figure 3, which depicts the equilibrium ERCs as functions of talent uncertainty σ_θ^2. The three differently shaded graphs visualize the effects of higher uncertainty about the manager's reputational concerns ($\sigma_T^2 \in \{1.6, 16, 49\}$). Confirming Lemma 2, increases in σ_T^2 reduce both ERCs. As shown before, the uncertainty about the manager's reputational concerns does not only affect the level of the ERCs, but also their slope. For low uncertainty about reputational motives ($\sigma_T^2 = 1.6$), the capital market earnings response β_P is generally increasing in talent uncertainty. For $\sigma_T^2 = 16$, the capital market ERC is decreasing within the range $\sigma_\theta^2 \in [0.03, 1.38]$. If the uncertainty

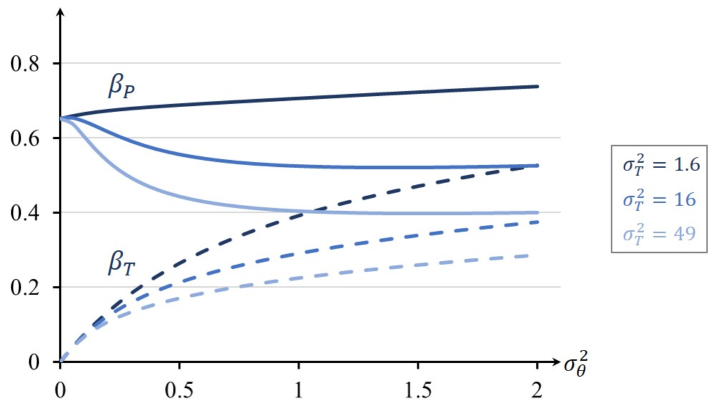

Figure 3 *Effects of higher talent uncertainty on market efficiency*
($\mu_P = \mu_T = 40$, $\sigma_\eta^2 = 0.8$, $\sigma_P^2 = 1$)

about the managers reputational concerns increases to $\sigma_T^2 = 49$, this range is widened to $[0.01, 1.53]$. In line with Proposition 4, β_T is increasing in talent uncertainty.

Expected reporting bias

We use our results to highlight implications for the expected bias level:

$$E[\tilde{b}] = E[b(\tilde{\eta}, \tilde{\theta}, \tilde{x}_P, \tilde{x}_T)] = \beta_P \cdot \mu_P + \beta_T \cdot \mu_T. \tag{11}$$

The derivative of the expected bias is thus given by:

$$\frac{dE[\tilde{b}]}{d\sigma_k^2} = \mu_P \cdot \frac{d\beta_P}{d\sigma_k^2} + \mu_T \cdot \frac{d\beta_T}{d\sigma_k^2} \quad \text{for } k \in \{\eta, \theta\}. \tag{12}$$

We can therefore use the comparative static results of the previous sections to analyze the effect of asset value and talent uncertainty on the expected bias level. We know from Proposition 3 that the capital market ERC is increasing and the labor market ERC is decreasing in the uncertainty about the asset value. Thus, it is unclear which of the two effects dominates. Corollary 4 clarifies how the statistical properties of the manager's reputational incentives affect the slope of the expected bias level.

Corollary 4 *The expected reporting bias is decreasing in the uncertainty about the firm's asset value if*

(i) the average benefits related to reputation are sufficiently high, i.e., $\mu_T > \underline{\mu}_T$*,*

(ii) markets have sufficient information about the reputational motives, i.e., $\sigma_T^2 < \bar{\sigma}_T^2$*.*

These results are intuitive. If the expected marginal benefits μ_T of increasing talent assessment are sufficiently high, it is likely that the manager chooses her report primarily to influence the labor market. The labor market's ERC is decreasing in the uncertainty about the asset value. Therefore, the expected bias is decreasing in σ_η^2 if μ_T is high.

To understand the second part of the proposition, consider the case that the uncertainty σ_T^2 about the manager's reputational concerns is high. Hence, any increase in the labor market's earnings response β_T is associated with significant incremental reporting noise. The labor market earnings response is therefore compressed: It takes low values and is hardly sensitive to changes in σ_η^2. As a consequence, the adjustment of the capital market ERC is leading the manager's bias choice. Higher uncertainty about the asset value implies higher expected reporting bias. Vice versa, the labor market's earnings response can only be dominant if there is low uncertainty about the manager's reputational motives.

The results of the previous section show that more uncertainty about talent σ_θ^2 generally implies higher responsiveness in the labor market, but may reduce earnings response in the capital market, i.e., $d\beta_P/d\sigma_\theta^2 < 0$ and $d\beta_T/d\sigma_\theta^2 > 0$. According to (12), this implies countervailing effects on the manager's bias choice: She increases the bias in response to the labor market reaction, but reduces it considering the attenuated reaction by financial investors. The total effect is ambiguous. Corollary 5 characterizes conditions for the expected reporting bias to decrease in talent uncertainty.

Corollary 5 *For* $\sigma_T^2 > 3 \cdot \sigma_P^2$ *and* $\sigma_\theta^2 \in [\underline{\sigma}_\theta^2, \bar{\sigma}_\theta^2]$*, the expected bias level is decreasing in the uncertainty about talent if and only if*

(i) the average benefits related to reputation are low on average, i.e., $\mu_T < \bar{\mu}_T$*,*

(ii) markets are sufficiently uncertain about the reputational motives, i.e., $\sigma_T^2 > \underline{\sigma}_T^2$*.*

According to Proposition 5, the capital market ERC decreases in talent uncertainty if the markets are sufficiently uncertain about the manager's reputational concerns ($\sigma_T^2 > 3 \cdot \sigma_P^2$). In this case, the expected bias level is decreasing in talent uncertainty $\sigma_\theta^2 \in [\underline{\sigma}_\theta^2, \bar{\sigma}_\theta^2]$ if (i) the average benefits of reputation are low or (ii) markets have little information on the manager's reputational concerns. Low values of μ_T ensure that the manager primarily reacts to the capital market ERC β_P, which is decreasing in σ_θ^2. Moreover, high uncertainty about reputational concerns σ_T^2 attenuates the labor market reaction. Thus, the manager's biasing decision is primarily led by the capital market response.

Note that the effects of higher uncertainty about the asset value and managerial talent stand in stark contrast. Increasing variance σ_η^2 reduces the expected bias if the manager's bias choice is led by the labor market reaction (i.e., for high μ_T and low σ_T^2); increasing variance σ_θ^2 reduces the expected bias if the manager's decision is primarily motivated by the capital market (i.e., for low μ_T and high σ_T^2).

To illustrate the results, we use the numerical examples introduced in the previous sections. The left-hand and right-hand sides of Figure 4 depict the expected reporting bias as a function of σ_η^2 and σ_θ^2 respectively. $E[\tilde{b}]$ is decreasing in σ_η^2 for low uncertainty about the manager's reputational concerns ($\sigma_T^2 = 1.6$) and increasing for high uncertainty $\sigma_T^2 \in \{16, 49\}$. In contrast, low uncertainty about reputational concerns ($\sigma_T^2 \in \{1.6, 16\}$) ensures that the expected reporting bias is increasing in σ_θ^2. If the uncertainty about the reputational motives is sufficiently high ($\sigma_T^2 = 49$), the expected bias is decreasing within the range $\sigma_\theta^2 \in [0.06, 0.55]$. Note that the expected bias even falls below its level without *any* talent uncertainty. Talent uncertainty and the corresponding reputational incentives can reduce reporting bias compared to a situation with observable managerial talent.

1.5 Should firms report on managers' contributions to firm value?

A prominent objective of financial reporting standards is the provision of decision-useful information for investors of the firm (Barth, Beaver, and Landsman, 2001).[32] For instance, the IASB Conceptual Framework for Financial Reporting states that reports should "provide financial information about the reporting entity that is useful to existing and potential investors, lenders and other creditors in making decisions" (IASB, 2018: OB10). A cen-

[32] Aside from the provision of decision-useful information, financial reporting standard setters pursue other objectives such as stewardship (e.g., Holthausen and Watts, 2001). Due to the limited focus of our model, we can only address standard setters' intentions to provide value-relevant information.

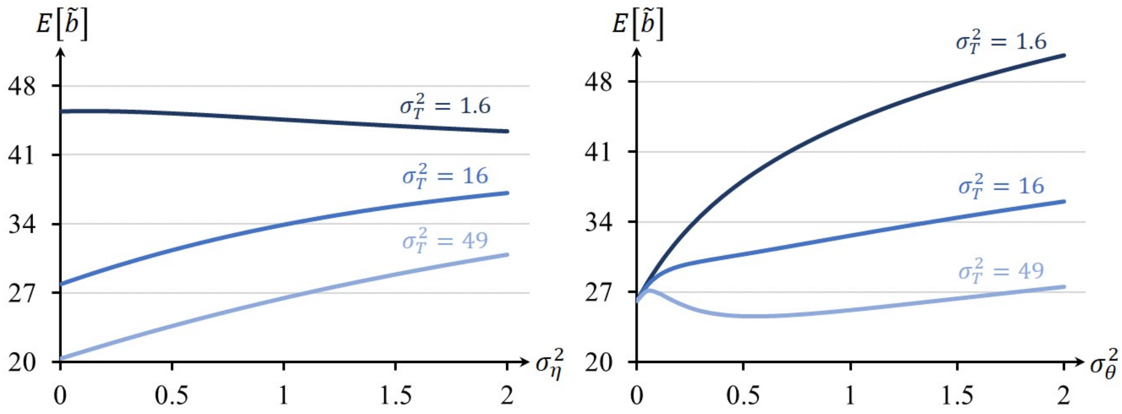

Figure 4 *Effects of higher uncertainty about firm value on the expected reporting bias* ($\mu_P = \mu_T = 40$, $\sigma_P^2 = 1$, $\sigma_\theta^2 = 1.1$, $\sigma_\eta^2 = 0.8$)

tral criterion for information included in reports is relevance in the sense of IASB (2018: QC6): It should be capable of changing users' decisions to buy, sell or hold equity and debt instruments. These objectives are closely related to the concepts of *value relevance* and *price efficiency* as formally defined in our model. Information is useful if it has high impact on the capital market price and reduces the investors' uncertainty about the firm value.

Information on the abilities of the firm's management seem to be material in many cases (see Johnson et al., 1985; Jenter, Matveyev, and Roth, 2016). Accordingly, the IASB classifies such information as relevant and mandates the disclosure of information "about how efficiently and effectively the reporting entity's management has discharged its responsibilities to use the entity's economic resources" (IASB, 2018: OB4). Moreover, the value-relevance criterion must be applied independent of the usefulness of the information for other stakeholders. The IASB acknowledges that there are other users of financial reports. However, reports are not primarily directed to these parties (IASB, 2018: OB10). This suggests that the reporting content should be tailored to the informational needs of investors and creditors and neglect the presence of other reporting users such as labor markets.

Such treatment disregards the interactions between reporting users identified in our study. Including information that is relevant for the managerial labor market motivates additional earnings management, which in turn dilutes information about the firm value. This can cause a reduction of value relevance and price efficiency in the capital market. To formalize our argument, consider a modified model setting, in which financial reporting standard setters require the management only to report on asset value η and to exclude any information about the talent component θ. While financial investors are still interested in the firm value $v = \eta + \theta$, the modified reporting objective alters the manager's costs of misreporting. In contrast to equation (2), the manager faces potential litigation costs if her report does not correctly reflect the firm's asset value:[33]

$$c(r) = \frac{1}{2} \cdot (r - \eta)^2. \tag{13}$$

The modified reporting objective has considerable implications for the equilibrium results summarized by the following lemma.

Lemma 5 *If the manager is supposed to report exclusively on the firm's asset value, we have the following unique linear equilibrium:*[34]

$$r^{\dagger} = \eta + \beta_P^{\dagger} \cdot x_P, \quad \beta_P^{\dagger} = \frac{\sigma_\eta^2}{\sigma_\eta^2 + \sigma_P^2 \cdot \beta_P^{\dagger 2}} \ \textit{and}\ \beta_T^{\dagger} = 0. \tag{14}$$

If managerial talent is not part of the reporting objective, the equilibrium financial report excludes any talent information. As a consequence, the report is irrelevant for the labor market and not used to update the a priori beliefs about talent, $\beta_T^{\dagger} = 0$. The interdependency between the capital market and labor market ERCs is dissolved.

A comparison of value relevance $\beta_P^{\dagger}$ and price efficiency $\Pi_P^{\dagger}$ in the capital market with the results of our main model highlights two differences. First, the financial report does not reflect managerial talent. Note that talent represents fundamental information for investors. In line with the IASB's argumentation, eliminating talent information therefore reduces the usefulness of the report in the capital market. However, there is a countervailing effect. In the absence of the labor market's earnings response, the manager's

[33] In this case, it is important that the manager has disaggregate information about the asset value and her talent. This could be because she receives a report on firm value v by the firm's internal accounting system and has private information about her talent θ. We come to similar conclusions if the manager does not precisely know the value of her talent but observes a noisy signal of the talent realization.

[34] We use $(\cdot)^{\dagger}$ to denote the equilibrium coefficients under the modified reporting objective.

incentives to misreport are attenuated. Therefore, the noise associated with the manager's bias choice is reduced. The latter effect allows better inferences on the firm's asset value and improves the usefulness of the report for financial investors. Proposition 6 identifies conditions under which the elimination of talent information improves value relevance and price efficiency in the capital market.[35]

Proposition 6 *Eliminating the talent information from reporting objectives improves*

(i) value relevance (i.e., $\beta_P^\dagger > \beta_P$) if the uncertainty about the manager's reputational concerns is sufficiently high compared to her financial incentives ($\sigma_T^2 > 4 \cdot \sigma_P^2$) and if talent uncertainty takes intermediate values $\sigma_\theta^2 \in [\sigma_L^2, \sigma_H^2]$.

(ii) price efficiency (i.e., $\Pi_P^\dagger > \Pi_P$) if the uncertainty about the manager's reputational concerns σ_T^2 is sufficiently high and if talent uncertainty takes intermediate values $\sigma_\theta^2 \in [\sigma_l^2, \sigma_h^2] \subset [\sigma_L^2, \sigma_H^2]$.

The proposition highlights that it may be beneficial for value relevance and price efficiency to remove information about managerial talent from financial reports. This is the case if there is high uncertainty about the manager's reputational concerns. Then, the incentives provided by the labor market induce significant reporting noise. Regulations that restrict the reporting content or leave firms discretion about the reported information can help to alleviate this problem by making reports less useful for the labor market. This stands in contrast to the IASB Conceptual Framework for Financial Reporting, which generally mandates to include (relevant) information on managerial contribution to firm value.

Moreover, the IASB Conceptual Framework assesses the information needs of reporting users aside from investors and creditors as largely irrelevant for the design of financial reports. Our results indicate that the presence of other users, such as labor markets, can critically influence the adequate choice of reporting standards. This is even the case if standard setters focus exclusively on capital market efficiency. If users provide incentives for managers to dissemble, this may cause additional reporting noise. As a consequence, the usefulness of the report in the capital market may be reduced. Standard setters should carefully consider potential detrimental effects of mandating the disclosure of information which might be relevant for other reporting users.

[35] In contrast to our main analysis, value relevance $\beta_P^\dagger$ and price efficiency $\Pi_P^\dagger$ are no longer identical if talent information is removed from reports. This is why Proposition 6 addresses both measures separately.

1.6 Extensions

Correlation of fundamentals

Empirical studies suggest a complementary relationship between the firm's asset value and managerial talent: Profitable firms with a large asset base are able to attract and retain talented managers. To capture such relationship, the analysis in this section allows for positive correlation $\rho \in [0,1]$ of asset value $\tilde{\eta}$ and managerial talent $\tilde{\theta}$.[36] We find that there is still a unique linear equilibrium characterized by the following market ERCs:

$$\beta_P = \frac{\sigma_v^2}{\sigma_v^2 + \sigma_P^2 \cdot \beta_P^2 + \sigma_T^2 \cdot \beta_T^2}, \quad \beta_T = \frac{\sigma_\theta^2 + \rho \cdot \sigma_\eta \cdot \sigma_\theta}{\sigma_v^2 + \sigma_P^2 \cdot \beta_P^2 + \sigma_T^2 \cdot \beta_T^2}. \tag{15}$$

Note that the correlation does structurally not affect the capital market ERC according to Proposition 1, but changes the form of the labor market ERC. To study the effect of increasing ρ on capital market efficiency, we distinguish direct and indirect effects:[37]

$$\frac{d\beta_P}{d\rho} = \underbrace{\frac{\partial \beta_P}{\partial \rho}}_{\equiv D_{P,\rho}} + \underbrace{\frac{d\beta_P}{d\beta_T} \cdot \frac{d\beta_T}{d\rho}}_{\equiv I_{P,\rho}}. \tag{16}$$

The direct effect $D_{P,\rho}$ represents the change of β_P implied by a marginal increase of ρ if the labor market does not adjust its earnings response β_T. We find that $D_{P,\rho}$ is strictly positive. The correlation ρ affects earnings response β_P only via the variance $\sigma_v^2 = \sigma_\eta^2 + \sigma_\theta^2 + 2 \cdot \rho \cdot \sigma_\eta \cdot \sigma_\theta$. A higher variance σ_v^2 raises financial investors' demand for information and implies higher earnings response, i.e., $d\beta_P/d\rho > 0$.

The indirect effect $I_{P,\rho}$ measures the adjustment of β_P that is mediated by the labor market earnings reaction $\beta_T(\rho)$. We find that this effect can be either positive or negative. Although the direct effect is strictly positive, the total effect of increasing correlation $d\beta_P/d\rho = D_{P,\rho} + I_{P,\rho}$ can be negative. Proposition 7 characterizes conditions which ensure that earnings response in the capital market is decreasing in correlation.

[36] If both components are perfectly correlated, learning about talent means learning about firm value.
[37] We focus on the analysis of capital market efficiency.

Proposition 7 *The effects of correlated fundamentals:*

a) *If the uncertainty about the manager's reputational concerns is sufficiently high compared to the uncertainty about her financial incentives ($\sigma_T^2 > 12 \cdot \sigma_P^2$) and talent uncertainty is relatively small ($\sigma_\eta^2 > 5 \cdot \sigma_\theta^2$), the capital market's earnings response is decreasing within a non-empty interval of correlation levels $[\underline{\rho}, \bar{\rho}] \subset [0, 1]$.*

b) *As uncertainty σ_T^2 about reputational concerns increases, the interval $[\underline{\rho}, \bar{\rho}]$ approaches the full range of positive correlation, $\lim_{\sigma_T^2 \to \infty} \underline{\rho} = 0$ and $\lim_{\sigma_T^2 \to \infty} \bar{\rho} = 1$.*

To provide intuition for these results, it is useful to consider the equilibrium labor market response. According to equation (15), higher correlation ρ has two countervailing effects on the equilibrium level of β_T. First, it makes the report more informative for the labor market, which is apparent from the numerator $Cov[\tilde{\theta}, \tilde{r}] = \sigma_\theta^2 + \rho \cdot \sigma_\eta \cdot \sigma_\theta$. The financial report is a noisy signal about firm value and comprises both asset value and talent. If these components are correlated, the asset value is not perceived as pure noise but conveys information about managerial talent. Second, higher correlation increases the variance of the firm value σ_v^2 and therefore the uncertainty associated with the report, $Var[\tilde{r}] = \sigma_v^2 + \sigma_P^2 \cdot \beta_P^2 + \sigma_T^2 \cdot \beta_T^2$. The report becomes less useful for the labor market.

It depends on the reporting environment whether the first or the second effect dominates. If talent uncertainty is comparably high, increasing correlation does not have a significant effect on the labor market's ability to learn about talent. Correlation primarily increases the uncertainty associated with the report. In this case, the denominator increases at a faster rate than the numerator. If however talent uncertainty is sufficiently low, the labor market hardly uses the report. In this case, even a small increase in correlation improves the labor market's learning about talent significantly.

Proposition 7 characterizes the latter case: If the labor market ERC β_T increases in correlation ρ, this provides additional incentives to bias the financial report. As a consequence, the financial report is a noisier signal of firm value. This is particularly the case if there is high uncertainty about the manager's reputational concerns σ_T^2. For $\sigma_\eta^2 > 5 \cdot \sigma_\theta^2$ and $\sigma_T^2 > 12 \cdot \sigma_P^2$, this effect is strong enough to make the capital market reduce its weight on the financial report within a range of correlation levels $[\underline{\rho}, \bar{\rho}]$. This interval is widened and finally approaches the full range of positive correlation if the uncertainty about the manager's reputational concerns is sufficiently high.

Multiple users of financial reports

The previous analysis can be extended to more than two users of financial reports. In this section, we use a generalized model to study how the number of the reporting users and their objectives affect capital market efficiency. In contrast to our main analysis, assume that the manager issues her report to the capital market ($a = 0$) and n additional risk-neutral users ($a = 1, ..., n$). Addressee $a \in A \equiv \{0, ..., n\}$ is interested in a specific subset of assets of the firm, which contribute to firm value. For any subgroup of reporting users $M \in \mathfrak{P}(A)$, let $\tilde{v}_M$ denote the component of the firm value which constitutes fundamental information for all users $a \in M$ while it is irrelevant to any user $a \in A/M$.[38] This defines a disaggregation of firm value into disjoint components, $\tilde{v} \equiv \sum_{M\in\mathfrak{P}(A)} \tilde{v}_M$. As in our main analysis, we assume that each value component is normally distributed, $\tilde{v}_M \sim N(0, \sigma_M^2)$. Components are mutually independent.[39] We denote $\sigma_v^2 = \sum_{M\in\mathfrak{P}(A)} \sigma_M^2$.

Moreover, define $S_a \equiv \{M \in \mathfrak{P}(A)|\ a \in M\}$ the subgroups of reporting users which contain user $a \in A$ and $\tilde{v}_a \equiv \sum_{M\in S_a} \tilde{v}_M$ his aggregate objective. It is reasonable to assume that the capital market is interested in all aspects of firm value, i.e., $\tilde{v}_0 = \tilde{v}$. After observing the financial report, each user $a \in A$ defines a price P_a reflecting the publicly available information about his objective, $P_a = E[\tilde{v}_a|r]$. The manager chooses her reporting bias b anticipating all users' reactions. She is interested in the outcomes of all reporting users:

$$U = \sum_{a\in A} x_a \cdot P_a - \frac{1}{2} \cdot b^2. \tag{17}$$

The manager privately learns the realizations of the incentive weights x_a. All reporting users hold identical beliefs about their prior distribution: $(\tilde{x}_a)_{a\in A}$ follow a multivariate normal distribution and are mutually independent with $\tilde{x}_a \sim N(\mu_a, \sigma_a^2)$. We define efficiency measures analogously to our main analysis: The ERC β_a measures how closely the price P_a is linked to the financial report, $\beta_a \equiv dP_a/dr$.

[38] $\mathfrak{P}(\cdot)$ denotes the power set of a given set, i.e., it is the set of all subsets.

[39] Our main analysis constitutes a special case of this general setup. The asset value represents fundamental information only for financial investors while managerial talent is fundamental in both markets, i.e., $\tilde{v} = \tilde{v}_{\{P\}} + \tilde{v}_{\{P,T\}}$ with independent components $\tilde{v}_{\{P\}} = \tilde{\eta}$ and $\tilde{v}_{\{P,T\}} = \tilde{\theta}$.

Lemma 6 *There exists a unique linear equilibrium characterized by:*

$$b = \sum_{a \in A} \beta_a \cdot x_a \;\; and \;\; \beta_a = \frac{\sum\limits_{M \in S_a} \sigma_M^2}{\sigma_v^2 + \beta_a^2 \cdot \sum\limits_{s \in A} \gamma^{(sa)2} \cdot \sigma_s^2}, \tag{18}$$

where $\gamma^{(sa)} = Var[\tilde{v}_s]/Var[\tilde{v}_a]$ *measures the relative uncertainty associated with the objectives of the reporting users s and a.*

Note that the relative size of the equilibrium ERCs represents the relative uncertainty about the users' objectives, i.e., $\beta_s = \gamma^{(sa)} \cdot \beta_a$. To highlight implications for capital market efficiency, we focus on the financial investors' ERC β_0.

Corollary 6 *The capital market ERC* β_0 *is decreasing if*

(i) a reporting user $a = n + 1$ *is added who is interested in part of the firm value, i.e.,* $|S_{n+1}| > 0$*, and provides (uncertain) incentives to bias the report, i.e.,* $\sigma_{n+1}^2 > 0$.

(ii) user $a \in A/\{0\}$ *is interested in a different objective with higher relative uncertainty.*

We can conclude that increasing the number of reporting users or the uncertainty about the users' objectives generally reduces capital market efficiency. As illustrated in our main analysis, the effect of higher uncertainty about firm value on the capital market ERCs depends on the origin of this uncertainty. For $M \in \mathfrak{P}(A)$, let

$$A_M \equiv \left\{ a \in M \,\middle|\, \gamma^{(a0)} < 2/3 \right\} \tag{19}$$

denote the set of reporting users who are interested in $\tilde{v}_M$ and whose objective is associated with relatively low uncertainty. More precisely, the definition requires that the uncertainty about the objective of a user is smaller than two thirds of the aggregate uncertainty about firm value. This helps us to characterize settings where higher uncertainty about firm value reduces capital market efficiency.

Proposition 8 *For* $M \in \mathfrak{P}(A)$*, the capital market ERC* β_0 *is decreasing in uncertainty about the value component* $\tilde{v}_M$ *if* A_M *is non-empty and the following condition holds:*

$$\sum_{a \in A_M} (-w_a) \cdot \sigma_a^2 > \sum_{a \in A/A_M} w_a \cdot \sigma_a^2, \;\; where \;\; w_a \equiv \begin{cases} (3 \cdot \gamma^{(a0)} - 2) \cdot \gamma^{(a0)} & for \;\; a \in M \\ 3 \cdot \gamma^{(a0)2} & for \;\; a \notin M \end{cases}. \tag{20}$$

Proposition 8 naturally generalizes the results of our main analysis. Capital market efficiency might decrease in the uncertainty about fundamental information $\tilde{v}_M$. This is the case if other reporting users exist who strive to learn about $\tilde{v}_M$ and whose objectives are associated with relatively low uncertainty, i.e., $\gamma^{(a0)} = Var[\tilde{v}_a]/\sigma_v^2 < 2/3$.[40] This condition ensures that, first, increasing the variance σ_M^2 does not only raise the information demand of financial investors but also of other users and, second, that σ_M^2 has a stronger effect on these users' ERCs than on the capital market ERC. Third, condition (20) requires that the aggregate uncertainty $(\sigma_a^2)_{a\in A_M}$ associated with the incentives provided by the competing reporting users must be sufficiently high. Under these three conditions the indirect effects of increasing the uncertainty σ_M^2 dominate the direct effect. Although financial investors have higher demand for information, the additional reporting bias induced by other reporting users significantly dilutes information on firm value. As a consequence, capital market efficiency is reduced.

1.7 Conclusion

We study managers' reporting bias in the presence of financial incentives and reputational concerns. Our analysis identifies interactions of both types of incentives assuming that capital and labor markets are uncertain about managers' reporting objectives: The use of the financial report in one market motivates noisy bias and reduces the value of the report in the other market. As a consequence, the presence of both financial incentives and reputational concerns reduces financial and labor market efficiency compared to settings where managers encounter only one type of incentives. Furthermore, our results highlight the subtle role of fundamental uncertainty in real reporting environments with multiple reporting users. When financial reports are processed by a single user, increasing fundamental uncertainty creates additional demand for information and improves value relevance and price efficiency (e.g., Fischer and Verrecchia, 2000). Our results show that this conclusion may not be valid if multiple stakeholders have a joint interest in a subgroup of the firm's assets and use financial reports to learn about these assets. In this case, increasing fundamental uncertainty has countervailing effects. First, each reporting user

[40] This observation is in line with the results of Proposition 5. The capital market ERC can only decrease in σ_θ^2 as far as $\sigma_\theta^2 < 2 \cdot \sigma_\eta^2$, which is equivalent to $\sigma_\theta^2/\sigma_v^2 < 2/3$.

assigns higher weight to the report, reacting to the additional demand for information. Second, the additional attention provides incentives to bias the report, which increases reporting noise. Considering managers' financial and reputational incentives, we find that higher uncertainty about managerial talent generally improves labor market efficiency, but may decrease value relevance and price efficiency in the capital market. This is particularly the case if markets are sufficiently uncertain about managers' reputational motives and if talent uncertainty is low compared to the overall fundamental uncertainty.

Our results have implications for standard setters' intentions to provide relevant information to investors and creditors. We characterize settings in which the value relevance of financial reports can be improved by eliminating talent information – even if this information is relevant to financial investors. What seems to be a contradiction can be explained by the reporting noise associated with managers' reputational concerns: Making reports less meaningful for labor markets mitigates incentives to dissemble and may therefore enhance investors' insights into firm fundamentals. A practical example is the standard setters' choice between different measurement concepts for assets. For instance, standard setters might require recording certain groups of assets at their value in use, which is typically calculated as net present value of future cash flows generated *in combination with the firm's given assets*.[41] Arguably, talented managers employ available assets in a more efficient way, which results in higher value in use. The value in use measurement is therefore informative about managerial talent. In contrast, fair value measurement does conceptually not convey information about the influence of the firm's management: Fair values represent (market) prices which do not reflect potential complementarities with the firm's other assets.

On a more general level, our results show that capital market efficiency is not necessarily improved if standard setters implement recognition and measurement rules that provide a more accurate depiction of firm value. In this regard, our results show similarities to existing work on relevance-reliability trade offs: A more precise depiction of firm value in financial reports may be undesirable if the corresponding standards offer managers additional discretion to bias reports. In line with this observation, we show that more precise measures of firm value may increase reporting bias. However, reporting bias in our setting does not result from increased leeway in accounting but from additional

[41] IAS 36 requires firms to potentially report assets' value in use when conducting impairment tests.

reporting users, which are interested in the supplemental information and add incentives to bias financial reports.

Following this logic, our analysis indicates risks of extending statutory reporting requirements. In an attempt to increase transparency and to provide a complete picture of firm assets, standard setters such as the IASB mandate the disclosure of information that affects investors' and creditors' decisions. However, if additional information is useful for various stakeholders, a more complete depiction of firm value may create complex reporting incentives, which aggravate the investors' problem to understand and back out reporting bias. This may be one reason for the mixed empirical evidence of value-relevance studies: Although reporting requirements have been extended and refined over the past decades, there is little evidence of improved value relevance of financial reports in capital markets (e.g., Francis and Schipper, 1999; Barth, Beaver, and Landsman, 2001; Gu, 2007). Existing literature discusses potential reasons such as the increasing relevance of intangible assets. This analysis shows that additional reporting noise might have contributed to this development: Financial reports have become a comprehensive instrument for managers to communicate with the firms' stakeholders. This creates implicit incentives to bias reports. Recent empirical findings confirm the practical importance of reporting noise (Beyer, Guttman, and Marinovic, 2018; Ferri, Zheng, and Zou, 2018). Our results could thus be an interesting starting point for empirical work to study interactions in the capital and labor markets' use of financial reports.

Appendix

Proof of Proposition 1

We restrict our analysis to linear equilibria, i.e., the manager's biasing strategy as well as the market outcomes are linear functions of the available information:

$$b(v, x_P, x_T) = \lambda + \lambda_\eta \cdot \eta + \lambda_\theta \cdot \theta + \lambda_P \cdot x_P + \lambda_T \cdot x_T, \tag{21}$$

$$P(r) = \alpha_P + \beta_P \cdot r, \;\; T(r) = \alpha_T + \beta_T \cdot r. \tag{22}$$

Given the linear strategies, the manager's objective (4) becomes:

$$U = x_P \cdot (\hat{\alpha}_P + \hat{\beta}_P \cdot r) + x_T \cdot (\hat{\alpha}_T + \hat{\beta}_T \cdot r) - \frac{1}{2} \cdot (r - v)^2. \tag{23}$$

The optimal bias level is given by:

$$r = v + \hat{\beta}_P \cdot x_P + \hat{\beta}_T \cdot x_T. \tag{24}$$

A comparison with (21) shows:

$$\lambda = 0, \;\; \lambda_\eta = \lambda_\theta = 1, \;\; \lambda_P = \hat{\beta}_P \text{ and } \lambda_T = \hat{\beta}_T. \tag{25}$$

Given linear beliefs about the manager's reporting strategy, the market outcomes (3) to the report are given by:

$$P = \frac{\hat{\lambda}_\eta \cdot \sigma_\eta^2 + \hat{\lambda}_\theta \cdot \sigma_\theta^2}{\hat{\lambda}_\eta^2 \cdot \sigma_\eta^2 + \hat{\lambda}_\theta^2 \cdot \sigma_\theta^2 + \hat{\lambda}_P^2 \cdot \sigma_P^2 + \hat{\lambda}_T^2 \cdot \sigma_T^2} \cdot (r - (\hat{\lambda} + \hat{\lambda}_P \cdot \mu_P + \hat{\lambda}_T \cdot \mu_T)), \tag{26}$$

$$T = \frac{\hat{\lambda}_\theta \cdot \sigma_\theta^2}{\hat{\lambda}_\eta^2 \cdot \sigma_\eta^2 + \hat{\lambda}_\theta^2 \cdot \sigma_\theta^2 + \hat{\lambda}_P^2 \cdot \sigma_P^2 + \hat{\lambda}_T^2 \cdot \sigma_T^2} \cdot (r - (\hat{\lambda} + \hat{\lambda}_P \cdot \mu_P + \hat{\lambda}_T \cdot \mu_T)). \tag{27}$$

Comparing the equilibrium market strategies with (22) yields:

$$\alpha_P = -(\hat{\lambda} + \hat{\lambda}_P \cdot \mu_P + \hat{\lambda}_T \cdot \mu_T) \cdot \beta_P, \;\; \alpha_T = -(\hat{\lambda} + \hat{\lambda}_P \cdot \mu_P + \hat{\lambda}_T \cdot \mu_T) \cdot \beta_T, \tag{28}$$

$$\beta_P = \frac{\hat{\lambda}_\eta \cdot \sigma_\eta^2 + \hat{\lambda}_\theta \cdot \sigma_\theta^2}{\Omega}, \; \beta_T = \frac{\hat{\lambda}_\theta \cdot \sigma_\theta^2}{\Omega}, \tag{29}$$

$$\text{where } \; \Omega = \hat{\lambda}_\eta^2 \cdot \sigma_\eta^2 + \hat{\lambda}_\theta^2 \cdot \sigma_\theta^2 + \hat{\lambda}_P^2 \cdot \sigma_P^2 + \hat{\lambda}_T^2 \cdot \sigma_T^2.$$

In equilibrium, the conjectures must be self-fulfilling. Substituting (25) into the above coefficients yields:

$$\alpha_P = -(\mu_P \cdot \beta_P + \mu_T \cdot \beta_T) \cdot \beta_P, \;\; \alpha_T = -(\mu_P \cdot \beta_P + \mu_T \cdot \beta_T) \cdot \beta_T, \tag{30}$$

$$\beta_P = \frac{\sigma_v^2}{\sigma_v^2 + \sigma_P^2 \cdot \beta_P^2 + \sigma_T^2 \cdot \beta_T^2} \; \text{ and } \; \beta_T = \frac{\sigma_\theta^2}{\sigma_v^2 + \sigma_P^2 \cdot \beta_P^2 + \sigma_T^2 \cdot \beta_T^2}. \tag{31}$$

The equilibrium conditions obviously imply:

$$\beta_T = \frac{Cov[\tilde{\theta}, \tilde{r}]}{Cov[\tilde{v}, \tilde{r}]} \cdot \beta_P = \frac{\sigma_\theta^2}{\sigma_v^2} \cdot \beta_P. \tag{32}$$

Thus, there is a one-to-one mapping between the capital market equilibrium ERC β_P and all other equilibrium coefficients. To show existence and uniqueness of the equilibrium, it is sufficient to prove that there is a unique value of β_P solving:

$$\beta_P = \frac{\sigma_v^2}{\sigma_v^2 + \sigma_P^2 \cdot \beta_P^2 + \sigma_T^2 \cdot \beta_T^2}. \tag{33}$$

Substitution of (32) and rearranging terms yields:

$$\left(\sigma_P^2 + \frac{\sigma_\theta^4}{\sigma_v^4} \cdot \sigma_T^2\right) \cdot \beta_P^3 + \sigma_v^2 \cdot (\beta_P - 1) = 0. \tag{34}$$

Note that the left-hand side of (34) is strictly increasing in β_P. It becomes strictly negative for $\beta_P = 0$ and strictly positive for $\beta_P = 1$. Continuity of the equilibrium condition guarantees that (34) has a unique solution $\beta_P \in (0, 1)$. □

Proof of Corollary 1

Consider the measures of price efficiency defined in (6). Assuming linear strategies according to (21) and (22), these measures have the following form:

$$\Pi_P = \frac{Cov[\tilde{v},\tilde{P}]^2}{Var[\tilde{v}]\cdot Var[\tilde{P}]} = \frac{(\lambda_\eta \cdot \sigma_\eta^2 + \lambda_\theta \cdot \sigma_\theta^2)^2}{\sigma_v^2 \cdot (\lambda_\eta^2 \cdot \sigma_\eta^2 + \lambda_\theta^2 \cdot \sigma_\theta^2 + \lambda_P^2 \cdot \sigma_P^2 + \lambda_T^2 \cdot \sigma_T^2)}, \tag{35}$$

$$\Pi_T = \frac{Cov[\tilde{\theta},\tilde{T}]^2}{Var[\tilde{\theta}]\cdot Var[\tilde{T}]} = \frac{\lambda_\theta^2 \cdot \sigma_\theta^2}{\lambda_\eta^2 \cdot \sigma_\eta^2 + \lambda_\theta^2 \cdot \sigma_\theta^2 + \lambda_P^2 \cdot \sigma_P^2 + \lambda_T^2 \cdot \sigma_T^2}. \tag{36}$$

Substituting the equilibrium strategies according to Proposition 1 yields:

$$\Pi_P = \beta_P \text{ and } \Pi_T = \frac{\sigma_\theta^2}{\sigma_v^2 + \lambda_P^2 \cdot \sigma_P^2 + \lambda_T^2 \cdot \sigma_T^2} = \beta_T. \tag{37}$$

□

Proof of Lemma 1

The benchmark cases with either financial incentives or reputational concerns are special cases of the general model for $\mu_P = \sigma_P^2 = 0$ and $\mu_T = \sigma_T^2 = 0$. The proof of Lemma 1 follows from our general analysis. □

Proof of Corollary 2

The relationship between β_P and β_T in a) has already been established in (32). Furthermore, the proof of Proposition 1 shows that the equilibrium capital market ERC is bounded, $0 < \beta_P < 1$. Using the result in a), β_T is strictly positive and bounded by $\frac{\sigma_\theta^2}{\sigma_v^2}$. □

Proof of Proposition 2

The proof follows directly from Lemma 2. The equilibrium ERCs are independent of μ_P and μ_T but strictly decreasing in σ_P^2 and σ_T^2. As the benchmark ERCs β_P^B and β_T^B reflect the special cases for $\sigma_T^2 = 0$ and $\sigma_P^2 = 0$ respectively, the ERCs β_P and β_T in the general model must take lower values, i.e., $\beta_P^B > \beta_P$ and $\beta_T^B > \beta_T$. □

Proof of Lemma 2

We use the implicit function theorem to show comparative static results with regard to σ_k^2, $k \in \{P, T\}$. Using the result of Corollary 2 a), the equilibrium conditions for β_P and β_T according to Proposition 1 can be stated in the following form:

$$F_P(\sigma_k^2, \beta_P(\sigma_k^2)) \equiv \left(\sigma_P^2 + \frac{\sigma_\theta^4}{\sigma_v^4} \cdot \sigma_T^2\right) \cdot \beta_P^3 + \sigma_v^2 \cdot (\beta_P - 1) = 0, \tag{38}$$

$$F_T(\sigma_k^2, \beta_T(\sigma_k^2)) \equiv \left(\frac{\sigma_v^4}{\sigma_\theta^4} \cdot \sigma_P^2 + \sigma_T^2\right) \cdot \beta_T^3 + \sigma_v^2 \cdot \beta_T - \sigma_\theta^2 = 0. \tag{39}$$

This reformulation of the equilibrium conditions dissolves the interdependency between the equilibrium ERCs: F_P characterizes β_P without referring to β_T; analogously, F_T defines β_T without referring to the capital market ERC. We obtain:

$$\frac{d\beta_P}{d\sigma_P^2} = -\frac{\partial F_P / \partial \sigma_P^2}{\partial F_P / \partial \beta_P} = -\frac{\beta_P^3}{3 \cdot \left(\sigma_P^2 + \frac{\sigma_\theta^4}{\sigma_v^4} \cdot \sigma_T^2\right) \cdot \beta_P^2 + \sigma_v^2} < 0, \tag{40}$$

$$\frac{d\beta_P}{d\sigma_T^2} = -\frac{\partial F_P / \partial \sigma_T^2}{\partial F_P / \partial \beta_P} = -\frac{\sigma_\theta^4}{\sigma_v^4} \cdot \frac{\beta_P^3}{3 \cdot \left(\sigma_P^2 + \frac{\sigma_\theta^4}{\sigma_v^4} \cdot \sigma_T^2\right) \cdot \beta_P^2 + \sigma_v^2} < 0, \tag{41}$$

$$\frac{d\beta_T}{d\sigma_P^2} = -\frac{\partial F_T / \partial \sigma_P^2}{\partial F_T / \partial \beta_T} = -\frac{\sigma_v^4}{\sigma_\theta^4} \cdot \frac{\beta_T^3}{3 \cdot \left(\frac{\sigma_v^4}{\sigma_\theta^4} \cdot \sigma_P^2 + \sigma_T^2\right) \cdot \beta_T^2 + \sigma_v^2} < 0, \tag{42}$$

$$\frac{d\beta_T}{d\sigma_T^2} = -\frac{\partial F_T / \partial \sigma_T^2}{\partial F_T / \partial \beta_T} = -\frac{\beta_T^3}{3 \cdot \left(\frac{\sigma_v^4}{\sigma_\theta^4} \cdot \sigma_P^2 + \sigma_T^2\right) \cdot \beta_T^2 + \sigma_v^2} < 0. \tag{43}$$

□

Proof of Corollary 3

Based on the implicit equilibrium conditions according to Proposition 1, we interpret the equilibrium ERC in one of the markets as a function of the model parameters and of the ERC in the other market, i.e., $\beta_P = \beta_P(\sigma_k^2, \beta_T(\sigma_k^2))$ and $\beta_T = \beta_T(\sigma_k^2, \beta_P(\sigma_k^2))$ with $k \in \{\eta, \theta\}$. Thus, varying the parameter value σ_k^2 has a direct effect on each of the equilibrium ERCs as well as an indirect effect:

$$\frac{d\beta_m}{d\sigma_k^2} = \underbrace{\frac{\partial\beta_m}{\partial\sigma_k^2}}_{:=D_{m,k}} + \underbrace{\frac{d\beta_m}{d\beta_n} \cdot \frac{d\beta_n}{d\sigma_k^2}}_{:=I_{m,k}} \quad \text{for } m,n \in \{P,T\}, \quad m \neq n. \tag{44}$$

The direct effect reflects the change in the ERC if the other market does not adjust its earnings response. The indirect effect represents the change in the ERC as a result of the other market's adjustment. □

Proof of Lemma 3 and 4

Rearranging the equilibrium conditions (8) according to Proposition 1 yields:

$$G_P(\sigma_k^2, \beta_P(\sigma_k^2, \beta_T), \beta_T) \equiv \sigma_P^2 \cdot \beta_P^3 + (\sigma_v^2 + \sigma_T^2 \cdot \beta_T^2) \cdot \beta_P - \sigma_v^2 = 0, \tag{45}$$

$$G_T(\sigma_k^2, \beta_P, \beta_T(\sigma_k^2, \beta_P)) \equiv \sigma_T^2 \cdot \beta_T^3 + (\sigma_v^2 + \sigma_P^2 \cdot \beta_P^2) \cdot \beta_T - \sigma_\theta^2 = 0. \tag{46}$$

The direct effect of σ_k^2 on the capital market ERC β_P reflects the change in the capital market ERC holding the labor market response β_T constant ($k \in \{\eta, \theta\}$). To analyze the sign of $D_{P,k}$, we therefore neglect the adjustment of β_T in response to a change in σ_k^2:

$$D_{P,\eta} = \frac{\partial\beta_P}{\partial\sigma_\eta^2} = -\frac{\partial G_P/\partial\sigma_\eta^2}{\partial G_P/\partial\beta_P} = \frac{1-\beta_P}{\sigma_v^2 + 3 \cdot \sigma_P^2 \cdot \beta_P^2 + \sigma_T^2 \cdot \beta_T^2} > 0, \tag{47}$$

$$D_{P,\theta} = \frac{\partial\beta_P}{\partial\sigma_\theta^2} = -\frac{\partial G_P/\partial\sigma_\theta^2}{\partial G_P/\partial\beta_P} = \frac{1-\beta_P}{\sigma_v^2 + 3 \cdot \sigma_P^2 \cdot \beta_P^2 + \sigma_T^2 \cdot \beta_T^2} > 0. \tag{48}$$

According to Corollary 2, β_P is smaller than 1. As a consequence, the direct effects have positive sign. Analogously, we evaluate the direct effects of σ_k^2 on the labor market ERC assuming that β_P is constant:

$$D_{T,\eta} = \frac{\partial\beta_T}{\partial\sigma_\eta^2} = -\frac{\partial G_T/\partial\sigma_\eta^2}{\partial G_T/\partial\beta_T} = -\frac{\beta_T}{\sigma_v^2 + \sigma_P^2 \cdot \beta_P^2 + 3 \cdot \sigma_T^2 \cdot \beta_T^2} < 0, \tag{49}$$

$$D_{T,\theta} = \frac{\partial\beta_T}{\partial\sigma_\theta^2} = -\frac{\partial G_T/\partial\sigma_\theta^2}{\partial G_T/\partial\beta_T} = \frac{1-\beta_T}{\sigma_v^2 + \sigma_P^2 \cdot \beta_P^2 + 3 \cdot \sigma_T^2 \cdot \beta_T^2} > 0. \tag{50}$$

The signs of the direct effects follow from Corollary 2. To identify the signs of the indirect effects, notice that:

$$\frac{\partial\beta_P}{\partial\beta_T} = -\frac{\partial G_P/\partial\beta_T}{\partial G_P/\partial\beta_P} = -\frac{2\cdot\sigma_T^2\cdot\beta_P\cdot\beta_T}{\sigma_v^2+3\cdot\sigma_P^2\cdot\beta_P^2+\sigma_T^2\cdot\beta_T^2} < 0, \tag{51}$$

$$\frac{\partial\beta_T}{\partial\beta_P} = -\frac{\partial G_T/\partial\beta_P}{\partial G_T/\partial\beta_T} = -\frac{2\cdot\sigma_P^2\cdot\beta_P\cdot\beta_T}{\sigma_v^2+\sigma_P^2\cdot\beta_P^2+3\cdot\sigma_T^2\cdot\beta_T^2} < 0. \tag{52}$$

Moreover, we use the modified equilibrium conditions (38) and (39) to obtain the total effects of higher uncertainty on the equilibrium ERCs:

$$\frac{d\beta_P}{d\sigma_\eta^2} = -\frac{\partial F_P/\partial\sigma_\eta^2}{\partial F_P/\partial\beta_P} = \frac{2\cdot\sigma_\theta^4\cdot\sigma_T^2\cdot\beta_P^3+\sigma_v^6\cdot(1-\beta_P)}{\left(3\cdot\left(\sigma_P^2+\frac{\sigma_\theta^4}{\sigma_v^4}\cdot\sigma_T^2\right)\cdot\beta_P^2+\sigma_v^2\right)\cdot\sigma_v^6} > 0, \tag{53}$$

$$\frac{d\beta_P}{d\sigma_\theta^2} = -\frac{\partial F_P/\partial\sigma_\theta^2}{\partial F_P/\partial\beta_P} = -\frac{2\cdot\sigma_\theta^2\cdot\sigma_\eta^2\cdot\sigma_T^2\cdot\beta_P^3-\sigma_v^6\cdot(1-\beta_P)}{\left(3\cdot\left(\sigma_P^2+\frac{\sigma_\theta^4}{\sigma_v^4}\cdot\sigma_T^2\right)\cdot\beta_P^2+\sigma_v^2\right)\cdot\sigma_v^6}, \tag{54}$$

$$\frac{d\beta_T}{d\sigma_\eta^2} = -\frac{\partial F_T/\partial\sigma_\eta^2}{\partial F_T/\partial\beta_T} = -\frac{2\cdot\sigma_v^2\cdot\sigma_P^2\cdot\beta_T^3+\sigma_\theta^4\cdot\beta_T}{\left(3\cdot\left(\frac{\sigma_v^4}{\sigma_\theta^4}\cdot\sigma_P^2+\sigma_T^2\right)\cdot\beta_T^2+\sigma_v^2\right)\cdot\sigma_\theta^4} < 0, \tag{55}$$

$$\frac{d\beta_T}{d\sigma_\theta^2} = -\frac{\partial F_T/\partial\sigma_\theta^2}{\partial F_T/\partial\beta_T} = \frac{2\cdot\sigma_v^2\cdot\sigma_\eta^2\cdot\sigma_P^2\cdot\beta_T^3+\sigma_\theta^6\cdot(1-\beta_T)}{\left(3\cdot\left(\frac{\sigma_v^4}{\sigma_\theta^4}\cdot\sigma_P^2+\sigma_T^2\right)\cdot\beta_T^2+\sigma_v^2\right)\cdot\sigma_\theta^6} > 0. \tag{56}$$

This implies the following results:

$$I_{P,\eta} = \frac{\partial\beta_P}{\partial\beta_T}\cdot\frac{d\beta_T}{d\sigma_\eta^2} > 0,\;\; I_{P,\theta} = \frac{\partial\beta_P}{\partial\beta_T}\cdot\frac{d\beta_T}{d\sigma_\theta^2} < 0 \;\text{ and }\; I_{T,\eta} = \frac{\partial\beta_T}{\partial\beta_P}\cdot\frac{d\beta_P}{d\sigma_\eta^2} < 0. \tag{57}$$

Furthermore, we can conclude that:

$$sgn(I_{T,\theta}) = (-1)\cdot sgn(d\beta_P/d\sigma_\theta^2). \tag{58}$$

This sign depends on the model parameters as the numerical examples in section 1.4 illustrate. Moreover, we use the characteristics of β_P and β_T established in Corollary 2 to show that $d\beta_T/d\sigma_\theta^2 > d\beta_P/d\sigma_\theta^2$. According to (54) and (56) we find:

$$\begin{aligned}\frac{d\beta_T}{d\sigma_\theta^2} &= \frac{2\cdot\sigma_v^2\cdot\sigma_\eta^2\cdot\sigma_P^2\cdot\beta_T^3+\sigma_\theta^6\cdot(1-\beta_T)}{\left(3\cdot\left(\frac{\sigma_v^4}{\sigma_\theta^4}\cdot\sigma_P^2+\sigma_T^2\right)\cdot\beta_T^2+\sigma_v^2\right)\cdot\sigma_\theta^6} \\ &> \frac{\sigma_\theta^6\cdot(1-\beta_P)}{\left(3\cdot\left(\frac{\sigma_v^4}{\sigma_\theta^4}\cdot\sigma_P^2+\sigma_T^2\right)\cdot\beta_T^2+\sigma_v^2\right)\cdot\sigma_\theta^6} \\ &= \frac{\sigma_v^6\cdot(1-\beta_P)}{\left(3\cdot\left(\sigma_P^2+\frac{\sigma_\theta^4}{\sigma_v^4}\cdot\sigma_T^2\right)\cdot\beta_P^2+\sigma_v^2\right)\cdot\sigma_v^6} \\ &> -\frac{2\cdot\sigma_\theta^2\cdot\sigma_\eta^2\cdot\sigma_T^2\cdot\beta_P^3-\sigma_v^6\cdot(1-\beta_P)}{\left(3\cdot\left(\sigma_P^2+\frac{\sigma_\theta^4}{\sigma_v^4}\cdot\sigma_T^2\right)\cdot\beta_P^2+\sigma_v^2\right)\cdot\sigma_v^6} = \frac{d\beta_P}{d\sigma_\theta^2}.\end{aligned} \tag{59}$$

□

Proof of Proposition 3 and 4

The effect of higher uncertainty about asset value and managerial talent on β_P and β_T has already been established in the proof of Lemma 3 and 4. □

Proof of Proposition 5

Rearranging the equilibrium condition (38) yields:

$$\sigma_v^2\cdot(1-\beta_P) = \left(\sigma_P^2+\frac{\sigma_\theta^4}{\sigma_v^4}\cdot\sigma_T^2\right)\cdot\beta_P^3. \tag{60}$$

When substituting this expression into (54), we have:

$$\frac{d\beta_P}{d\sigma_\theta^2}\leq 0 \quad\Leftrightarrow\quad \underline{\sigma}_\theta^2\leq\sigma_\theta^2\leq\bar{\sigma}_\theta^2. \tag{61}$$

The threshold levels $\underline{\sigma}_\theta^2$ and $\bar{\sigma}_\theta^2$ are given by:

$$\underline{\sigma}_\theta^2 \equiv \frac{\sigma_T^2 - \sigma_P^2 - \Psi}{\sigma_P^2 + \sigma_T^2} \cdot \sigma_\eta^2, \quad \bar{\sigma}_\theta^2 \equiv \frac{\sigma_T^2 - \sigma_P^2 + \Psi}{\sigma_P^2 + \sigma_T^2} \cdot \sigma_\eta^2, \qquad (62)$$
$$\text{where } \Psi = \sqrt{(\sigma_T^2 - 3 \cdot \sigma_P^2) \cdot \sigma_T^2}.$$

The range $[\underline{\sigma}_\theta^2, \bar{\sigma}_\theta^2]$ of opposed market reactions only exists if $\sigma_T^2 - 3 \cdot \sigma_P^2 > 0$. It is easy to see that under this condition the lower bound $\underline{\sigma}_\theta^2$ is strictly positive. Moreover, increasing the uncertainty about the manager's reputational concerns widens this range while higher uncertainty about financial incentives narrows it:

$$\frac{d\underline{\sigma}_\theta^2}{d\sigma_P^2} = -\frac{2 - \frac{5 \cdot \sigma_T^2 - 3 \cdot \sigma_P^2}{2 \cdot \sqrt{(\sigma_T^2 - 3 \cdot \sigma_P^2) \cdot \sigma_T^2}}}{(\sigma_P^2 + \sigma_T^2)^2} \cdot \sigma_\eta^2 \cdot \sigma_T^2 > 0, \quad \frac{d\underline{\sigma}_\theta^2}{d\sigma_T^2} = \frac{2 - \frac{5 \cdot \sigma_T^2 - 3 \cdot \sigma_P^2}{2 \cdot \sqrt{(\sigma_T^2 - 3 \cdot \sigma_P^2) \cdot \sigma_T^2}}}{(\sigma_P^2 + \sigma_T^2)^2} \cdot \sigma_\eta^2 \cdot \sigma_P^2 < 0, \qquad (63)$$

$$\frac{d\bar{\sigma}_\theta^2}{d\sigma_P^2} = -\frac{2 + \frac{5 \cdot \sigma_T^2 - 3 \cdot \sigma_P^2}{2 \cdot \sqrt{(\sigma_T^2 - 3 \cdot \sigma_P^2) \cdot \sigma_T^2}}}{(\sigma_P^2 + \sigma_T^2)^2} \cdot \sigma_\eta^2 \cdot \sigma_T^2 < 0, \quad \frac{d\bar{\sigma}_\theta^2}{d\sigma_T^2} = \frac{2 + \frac{5 \cdot \sigma_T^2 - 3 \cdot \sigma_P^2}{2 \cdot \sqrt{(\sigma_T^2 - 3 \cdot \sigma_P^2) \cdot \sigma_T^2}}}{(\sigma_P^2 + \sigma_T^2)^2} \cdot \sigma_\eta^2 \cdot \sigma_P^2 > 0. \qquad (64)$$

The signs of these expressions follow from the fact that $\sigma_T^2 - 3 \cdot \sigma_P^2 > 0$ and thus:

$$2 - \frac{5 \cdot \sigma_T^2 - 3 \cdot \sigma_P^2}{2 \cdot \sqrt{(\sigma_T^2 - 3 \cdot \sigma_P^2) \cdot \sigma_T^2}} < 0. \qquad (65)$$

It is easy to see that:

$$\lim_{\sigma_T^2 \to \infty} \underline{\sigma}_\theta^2 = 0 \quad \text{and} \quad \lim_{\sigma_T^2 \to \infty} \bar{\sigma}_\theta^2 = 2 \cdot \sigma_\eta^2. \qquad (66)$$

□

Proof of Corollary 4

We have established in Proposition 3 that $d\beta_P/d\sigma_\eta^2 > 0$ and $d\beta_T/d\sigma_\eta^2 < 0$. Note that β_P and β_T do not depend on the average incentive weights μ_P and μ_T. It is therefore obvious that the derivative $dE[\tilde{b}]/d\sigma_\eta^2$ according to equation (12) is negative for sufficiently high values of μ_T that exceed a threshold value $\underline{\mu}_T$.

To show the second part of the proposition, we rearrange the equilibrium conditions (38) and (39) in the following way:

$$\beta_P^3 = \frac{\sigma_v^6 \cdot (1-\beta_P)}{\sigma_v^4 \cdot \sigma_P^2 + \sigma_\theta^4 \cdot \sigma_T^2}, \;\; \beta_T^3 = \frac{\sigma_\theta^4 \cdot (\sigma_\theta^2 - \sigma_v^2 \cdot \beta_T)}{\sigma_v^4 \cdot \sigma_P^2 + \sigma_\theta^4 \cdot \sigma_T^2}. \tag{67}$$

Substituting these identities into (53) and (55) yields:

$$\frac{d\beta_P}{d\sigma_\eta^2} = \frac{(\sigma_\eta^2 + \sigma_\theta^2)^2 \cdot \sigma_P^2 + 3 \cdot \sigma_\theta^4 \cdot \sigma_T^2}{((\sigma_\eta^2 + \sigma_\theta^2)^2 \cdot \sigma_P^2 + \sigma_\theta^4 \cdot \sigma_T^2) \cdot (\sigma_\eta^2 + \sigma_\theta^2)} \cdot \frac{(1-\beta_P) \cdot \beta_P}{3 - 2 \cdot \beta_P}, \tag{68}$$

$$\frac{d\beta_T}{d\sigma_\eta^2} = -\frac{2 \cdot (\sigma_\eta^2 + \sigma_\theta^2) \cdot \sigma_\theta^2 \cdot \sigma_P^2 - ((\sigma_\eta^2 + \sigma_\theta^2)^2 \cdot \sigma_P^2 - \sigma_\theta^4 \cdot \sigma_T^2) \cdot \beta_T}{((\sigma_\eta^2 + \sigma_\theta^2)^2 \cdot \sigma_P^2 + \sigma_\theta^4 \cdot \sigma_T^2) \cdot (3 \cdot \sigma_\theta^2 - 2 \cdot (\sigma_\eta^2 + \sigma_\theta^2) \cdot \beta_T)} \cdot \beta_T. \tag{69}$$

Moreover, we use Corollary 2 a) to obtain the following equation:

$$\frac{d\beta_T}{d\sigma_\eta^2} = -\frac{\sigma_\theta^2}{\sigma_\eta^2 + \sigma_\theta^2} \cdot \frac{2 \cdot \sigma_v^4 \cdot \sigma_P^2 - (\sigma_v^4 \cdot \sigma_P^2 - \sigma_\theta^4 \cdot \sigma_T^2) \cdot \beta_P}{(\sigma_v^4 \cdot \sigma_P^2 + 3 \cdot \sigma_\theta^4 \cdot \sigma_T^2) \cdot (1-\beta_P)} \cdot \frac{d\beta_P}{d\sigma_\eta^2}. \tag{70}$$

Thus, we have the following derivative of the expected bias with regard to σ_η^2:

$$\begin{aligned} \frac{dE[\tilde{b}]}{d\sigma_\eta^2} &= \frac{d\beta_P}{d\sigma_\eta^2} \cdot \mu_P + \frac{d\beta_T}{d\sigma_\eta^2} \cdot \mu_T \\ &= \left(1 - \frac{\mu_T}{\mu_P} \cdot \frac{\sigma_\theta^2}{\sigma_\eta^2 + \sigma_\theta^2} \cdot \frac{2 \cdot \sigma_v^4 \cdot \sigma_P^2 - (\sigma_v^4 \cdot \sigma_P^2 - \sigma_\theta^4 \cdot \sigma_T^2) \cdot \beta_P}{(\sigma_v^4 \cdot \sigma_P^2 + 3 \cdot \sigma_\theta^4 \cdot \sigma_T^2) \cdot (1-\beta_P)}\right) \cdot \frac{d\beta_P}{d\sigma_\eta^2} \cdot \mu_P. \end{aligned} \tag{71}$$

Proposition 3 establishes $d\beta_P/d\sigma_\eta^2 > 0$. Therefore, higher uncertainty about the asset value reduces the expected reporting bias if and only if:

$$\frac{\mu_T}{\mu_P} \cdot \frac{\sigma_\theta^2}{\sigma_\eta^2 + \sigma_\theta^2} \cdot \frac{2 \cdot \sigma_v^4 \cdot \sigma_P^2 - (\sigma_v^4 \cdot \sigma_P^2 - \sigma_\theta^4 \cdot \sigma_T^2) \cdot \beta_P}{(\sigma_v^4 \cdot \sigma_P^2 + 3 \cdot \sigma_\theta^4 \cdot \sigma_T^2) \cdot (1-\beta_P)} > 1. \tag{72}$$

To simplify this condition, we must distinguish two cases:

Case a) $(\mu_T \cdot \sigma_\theta^2 - \mu_P \cdot \sigma_v^2) \cdot \sigma_v^4 \cdot \sigma_P^2 - (3 \cdot \mu_P \cdot \sigma_v^2 + \mu_T \cdot \sigma_\theta^2) \cdot \sigma_\theta^4 \cdot \sigma_T^2 > 0$

Solving condition (72) for β_P yields:

$$\beta_P < 1 + \frac{\mu_T \cdot \sigma_\theta^2 \cdot (\sigma_v^4 \cdot \sigma_P^2 + \sigma_\theta^4 \cdot \sigma_T^2)}{(\mu_T \cdot \sigma_\theta^2 - \mu_P \cdot \sigma_v^2) \cdot \sigma_v^4 \cdot \sigma_P^2 - (3 \cdot \mu_P \cdot \sigma_v^2 + \mu_T \cdot \sigma_\theta^2) \cdot \sigma_\theta^4 \cdot \sigma_T^2}. \tag{73}$$

This is generally true because $\beta_P < 1$ according to Corollary 2. Thus, in this case, the expected bias level is generally decreasing in the uncertainty about the asset value.

Case b) $(\mu_T \cdot \sigma_\theta^2 - \mu_P \cdot \sigma_v^2) \cdot \sigma_v^4 \cdot \sigma_P^2 - (3 \cdot \mu_P \cdot \sigma_v^2 + \mu_T \cdot \sigma_\theta^2) \cdot \sigma_\theta^4 \cdot \sigma_T^2 < 0$

The condition that characterizes *Case b)* can be rearranged to:

$$\sigma_T^2 > \frac{(\mu_T \cdot \sigma_\theta^2 - \mu_P \cdot (\sigma_\eta^2 + \sigma_\theta^2)) \cdot (\sigma_\eta^2 + \sigma_\theta^2)^2 \cdot \sigma_P^2}{(\mu_P \cdot 3 \cdot (\sigma_\eta^2 + \sigma_\theta^2) + \mu_T \cdot \sigma_\theta^2) \cdot \sigma_\theta^4}. \tag{74}$$

Thus, *Case b)* applies for sufficiently high values of σ_T^2. The condition (72) can now be rearranged as follows:

$$\beta_P > 1 - \underbrace{\frac{\mu_T \cdot \sigma_\theta^2 \cdot (\sigma_v^4 \cdot \sigma_P^2 + \sigma_\theta^4 \cdot \sigma_T^2)}{(\mu_P \cdot \sigma_v^2 - \mu_T \cdot \sigma_\theta^2) \cdot \sigma_v^4 \cdot \sigma_P^2 + (3 \cdot \mu_P \cdot \sigma_v^2 + \mu_T \cdot \sigma_\theta^2) \cdot \sigma_\theta^4 \cdot \sigma_T^2}}_{\equiv H_\eta}. \tag{75}$$

It is easy to establish that:

$$\frac{dH_\eta}{d\sigma_T^2} = -\frac{2 \cdot \mu_T \cdot (\mu_P \cdot \sigma_v^2 + \mu_T \cdot \sigma_\theta^2) \cdot \sigma_\theta^6 \cdot \sigma_v^4 \cdot \sigma_P^2}{((\mu_P \cdot \sigma_v^2 - \mu_T \cdot \sigma_\theta^2) \cdot \sigma_v^4 \cdot \sigma_P^2 + (3 \cdot \mu_P \cdot \sigma_v^2 + \mu_T \cdot \sigma_\theta^2) \cdot \sigma_\theta^4 \cdot \sigma_T^2)^2} < 0. \tag{76}$$

Thus, the right-hand side of (75) is strictly increasing in σ_T^2. The left-hand side of (75) is strictly decreasing as shown in Lemma 2. As a consequence, condition (75) is fulfilled for a larger set of parameters if σ_T^2 decreases. Moreover, it is easy to see that $\lim_{\sigma_T^2 \to \infty} \beta_P = 0$ while $\lim_{\sigma_T^2 \to \infty}(1 - H_\eta) > 0$. This proves the existence of $\bar{\sigma}_T^2 \geq 0$ such that the expected reporting bias is decreasing in σ_η^2 for $\sigma_T^2 < \bar{\sigma}_T^2$. □

Proof of Corollary 5

According to equation (12) the slope of the expected reporting bias in talent uncertainty depends on the derivatives of both markets' ERCs. A negative slope of $E[\tilde{b}]$ therefore requires that $d\beta_P/d\sigma_\theta^2$ or $d\beta_T/d\sigma_\theta^2$ have negative sign. According to Proposition 4 we have $d\beta_T/d\sigma_\theta^2 > 0$. Any decrease of the expected reporting bias in talent uncertainty therefore arises from a declining ERC in the capital market. We can therefore restrict our analysis to the case $d\beta_P/d\sigma_\theta^2 < 0$. According to Proposition 5, we have:

$$\frac{d\beta_P}{d\sigma_\theta^2} < 0 \quad \Leftrightarrow \quad \left(\sigma_T^2 - 3\cdot\sigma_P^2 > 0 \quad \wedge \quad \sigma_\theta^2 \in [\underline{\sigma}_\theta^2, \bar{\sigma}_\theta^2]\right). \tag{77}$$

If this condition holds, the derivative $dE[\tilde{b}]/d\sigma_\theta^2$ according to equation (12) is negative for sufficiently low values of μ_T that fall below a threshold value $\bar{\mu}_T$. This proves the first part of the proposition.

As shown in Proposition 5, the condition (77) holds for a wider range of parameters if σ_T^2 increases. Substituting (67) into (54) and (56) yields:

$$\frac{d\beta_P}{d\sigma_\theta^2} = \frac{\sigma_v^4\cdot\sigma_P^2 - (2\cdot\sigma_\eta^2 - \sigma_\theta^2)\cdot\sigma_\theta^2\cdot\sigma_T^2}{(\sigma_v^4\cdot\sigma_P^2 + \sigma_\theta^4\cdot\sigma_T^2)\cdot\sigma_v^2}\cdot\frac{(1-\beta_P)\cdot\beta_P}{3-2\cdot\beta_P}, \tag{78}$$

$$\frac{d\beta_T}{d\sigma_\theta^2} = \frac{(3\cdot\sigma_\eta^2 + \sigma_\theta^2)\cdot\sigma_v^2\cdot\sigma_P^2 + \sigma_\theta^4\cdot\sigma_T^2 - ((2\cdot\sigma_\eta^2 + \sigma_\theta^2)\cdot\sigma_v^4\cdot\sigma_P^2 + \sigma_\theta^6\cdot\sigma_T^2)\cdot\frac{\beta_T}{\sigma_\theta^2}}{(\sigma_v^4\cdot\sigma_P^2 + \sigma_\theta^4\cdot\sigma_T^2)\cdot(3\cdot\sigma_\theta^2 - 2\cdot\sigma_v^2\cdot\beta_T)}\cdot\beta_T. \tag{79}$$

Thus, $d\beta_P/d\sigma_\theta^2 < 0$ requires that:

$$\sigma_v^4\cdot\sigma_P^2 - (2\cdot\sigma_\eta^2 - \sigma_\theta^2)\cdot\sigma_\theta^2\cdot\sigma_T^2 < 0. \tag{80}$$

Using Corollary 2, we can relate the derivatives $d\beta_P/d\sigma_\theta^2$ and $d\beta_T/d\sigma_\theta^2$:

$$\frac{d\beta_T}{d\sigma_\theta^2} = \frac{\sigma_\eta^2\cdot\beta_P}{\sigma_v^4\cdot(3-2\cdot\beta_P)} - \frac{(2\cdot\sigma_\eta^2 + \sigma_\theta^2)\cdot\sigma_v^2\cdot\sigma_P^2 + \frac{\sigma_\theta^6}{\sigma_v^2}\cdot\sigma_T^2}{(2\cdot\sigma_\eta^2 - \sigma_\theta^2)\cdot\sigma_\theta^2\cdot\sigma_T^2 - \sigma_v^4\cdot\sigma_P^2}\cdot\frac{d\beta_P}{d\sigma_\theta^2}. \tag{81}$$

Using this result, we obtain:

$$\begin{aligned}\frac{dE[\tilde{b}]}{d\sigma_\theta^2} &= \mu_P\cdot\frac{d\beta_P}{d\sigma_\theta^2} + \mu_T\cdot\frac{d\beta_T}{d\sigma_\theta^2}\\ &= \frac{\mu_T\cdot\sigma_\eta^2\cdot\beta_P}{\sigma_v^4\cdot(3-2\cdot\beta_P)} + \left(\mu_P - \mu_T\cdot\frac{(2\cdot\sigma_\eta^2 + \sigma_\theta^2)\cdot\sigma_v^2\cdot\sigma_P^2 + \frac{\sigma_\theta^6}{\sigma_v^2}\cdot\sigma_T^2}{(2\cdot\sigma_\eta^2 - \sigma_\theta^2)\cdot\sigma_\theta^2\cdot\sigma_T^2 - \sigma_v^4\cdot\sigma_P^2}\right)\cdot\frac{d\beta_P}{d\sigma_\theta^2}.\end{aligned} \tag{82}$$

Substituting $d\beta_P/d\sigma_\theta^2$ yields:

$$\frac{dE[\tilde{b}]}{d\sigma_\theta^2} < 0 \Leftrightarrow \quad \beta_P < 1 - \frac{\mu_T \cdot \frac{\sigma_\eta^2}{\sigma_v^2} \cdot (\sigma_v^4 \cdot \sigma_P^2 + \sigma_\theta^4 \cdot \sigma_T^2)}{H_\theta}, \tag{83}$$

where

$$H_\theta = \mu_P \cdot ((2 \cdot \sigma_\eta^2 - \sigma_\theta^2) \cdot \sigma_\theta^2 \cdot \sigma_T^2 - \sigma_v^4 \cdot \sigma_P^2) - \mu_T \cdot ((2 \cdot \sigma_\eta^2 + \sigma_\theta^2) \cdot \sigma_v^2 \cdot \sigma_P^2 + \frac{\sigma_\theta^6}{\sigma_v^2} \cdot \sigma_T^2).$$

It is easy to verify that $dH_\theta/d\sigma_T^2 < 0$. At the same time, β_P is strictly decreasing in σ_T^2 (see Lemma 2). Thus, the expected reporting bias is decreasing for a larger set of parameters if σ_T^2 increases or μ_T decreases. □

Proof of Lemma 5

Following the procedure of Proposition 1 with the modified cost function (2), we establish the equilibrium conditions stated in the lemma. □

Proof of Proposition 6

A comparison of the capital market ERCs according to Proposition 1 and Lemma 5 shows that the ERC with modified reporting objective corresponds to the ERC in our main model when there is no uncertainty about managerial talent, i.e., $\beta_P^\dagger = \beta_P|_{\sigma_\theta^2=0}$. It is therefore sufficient to study under which conditions the capital market ERC β_P in our main model falls below its level without talent uncertainty, $\beta_P < \beta_P|_{\sigma_\theta^2=0}$.

For this purpose, it is useful to refer to the explicit solution of β_P. Applying Cardano's formula to the polynomial equation (38) yields the following unique real root:

$$\beta_P = \sqrt[3]{A} \cdot \left(\sqrt[3]{\frac{1}{2} + \sqrt{\frac{1}{4} + \frac{1}{27} \cdot A}} + \sqrt[3]{\frac{1}{2} - \sqrt{\frac{1}{4} + \frac{1}{27} \cdot A}} \right) \tag{84}$$

with $A = \frac{(\sigma_\eta^2+\sigma_\theta^2)^3}{(\sigma_\eta^2+\sigma_\theta^2)^2 \cdot \sigma_P^2 + \sigma_\theta^4 \cdot \sigma_T^2}$. It is easy to see, that β_P is increasing in A. We therefore have:

$$\beta_P < \beta_P|_{\sigma_\theta^2=0} \quad \Leftrightarrow \quad A < A|_{\sigma_\theta^2=0} \quad \Leftrightarrow \quad \sigma_L^2 \le \sigma_\theta^2 \le \sigma_H^2 \tag{85}$$

with $\sigma_L^2 \equiv \frac{\sigma_T^2 - 2\cdot\sigma_P^2 + \sqrt{(\sigma_T^2 - 4\cdot\sigma_P^2)\cdot\sigma_T^2}}{\sigma_P^2} \cdot \frac{\sigma_\eta^2}{2}$ and $\sigma_H^2 \equiv \frac{\sigma_T^2 - 2\cdot\sigma_P^2 - \sqrt{(\sigma_T^2 - 4\cdot\sigma_P^2)\cdot\sigma_T^2}}{\sigma_P^2} \cdot \frac{\sigma_\eta^2}{2}$. This proves the first part of the proposition. With the modified reporting objective, value relevance $\beta_P^\dagger$ and price efficiency $\Pi_P^\dagger$ are not identical:

$$\Pi_P^\dagger = \frac{Cov[\tilde{v}, \tilde{P}^\dagger]^2}{Var[\tilde{v}] \cdot Var[\tilde{P}^\dagger]} = \frac{\sigma_\eta^2}{\sigma_v^2} \cdot \beta_P^\dagger. \tag{86}$$

For the second part of the proposition, we must study the following condition:

$$\Pi_P < \Pi_P^\dagger \quad \Leftrightarrow \quad \beta_P < \frac{\sigma_\eta^2}{\sigma_v^2} \cdot \beta_P^\dagger. \tag{87}$$

As $\sigma_\eta^2/\sigma_v^2 \leq 1$, this condition cannot be satisfied for $\sigma_\theta^2 \leq \sigma_L^2$ or $\sigma_\theta^2 \geq \sigma_H^2$. Proposition 5 shows that β_P has a local minimum in $\bar{\sigma}_\theta^2 \in [\sigma_L^2, \sigma_H^2]$. The corresponding value of A is:

$$A|_{\sigma_\theta^2 = \bar{\sigma}_\theta^2} = \frac{(\sigma_\eta^2 + \bar{\sigma}_\theta^2)^3}{2 \cdot \bar{\sigma}_\theta^2 \cdot \sigma_T^2 \cdot \sigma_\eta^2}. \tag{88}$$

We have already established that $\lim_{\sigma_T^2 \to \infty} \bar{\sigma}_\theta^2 = 2 \cdot \sigma_\eta^2$ and thus $\lim_{\sigma_T^2 \to \infty} A|_{\sigma_\theta^2 = \bar{\sigma}_\eta^2} = 0$. As a consequence, we have:

$$\lim_{\sigma_T^2 \to \infty} \beta_P = \lim_{A \to 0} \beta_P = 0. \tag{89}$$

On the other hand:

$$\lim_{\sigma_T^2 \to \infty} \frac{\sigma_\eta^2}{\sigma_\eta^2 + \bar{\sigma}_\theta^2} \cdot \beta_P^\dagger = \frac{1}{3} \cdot \beta_P|_{\sigma_\theta^2 = 0} > 0. \tag{90}$$

To see this, note that $\beta_P^\dagger = \beta_P|_{\sigma_\theta^2 = 0}$ is independent of σ_T^2 and $A|_{\sigma_\theta^2 = 0} > 0$. As a consequence, condition (87) is satisfied for $\sigma_\theta^2 = \bar{\sigma}_\theta^2$ if σ_T^2 is large enough. Due to continuity, this is true within a neighborhood $[\sigma_l^2, \sigma_h^2] \subset [\sigma_L^2, \sigma_H^2]$ of $\bar{\sigma}_\theta^2$. □

Proof of Proposition 7

Following the procedure used in the proof of Proposition 1, we establish the equilibrium ERCs according to equation (15). Using these implicit characterizations, we use Cardano's formula to find the explicit solution of β_P:

$$\beta_P = \sqrt[3]{A} \cdot \left(\sqrt[3]{\frac{1}{2} + \sqrt{\frac{1}{4} + \frac{1}{27} \cdot A}} + \sqrt[3]{\frac{1}{2} - \sqrt{\frac{1}{4} + \frac{1}{27} \cdot A}} \right), \tag{91}$$

$$\text{where } A = \frac{(\sigma_\eta^2 + \sigma_\theta^2 + 2 \cdot \rho \cdot \sigma_\eta \cdot \sigma_\theta)^3}{\sigma_P^2 \cdot (\sigma_\eta^2 + \sigma_\theta^2 + 2 \cdot \rho \cdot \sigma_\eta \cdot \sigma_\theta)^2 + (\sigma_\theta^2 + \rho \cdot \sigma_\eta \cdot \sigma_\theta)^2 \cdot \sigma_T^2}.$$

It is easy to see that β_P is strictly increasing in A. Moreover:

$$\frac{dA}{d\rho} \leq 0 \quad \Leftrightarrow \quad \rho \in [\underline{\rho}, \bar{\rho}] \tag{92}$$

$$\text{with } \underline{\rho} = \underline{\alpha} \cdot \tfrac{\sigma_\eta}{\sigma_\theta} - (1 + \underline{\alpha}) \cdot \tfrac{\sigma_\theta}{\sigma_\eta}, \ \bar{\rho} = \bar{\alpha} \cdot \tfrac{\sigma_\eta}{\sigma_\theta} - (1 + \bar{\alpha}) \cdot \tfrac{\sigma_\theta}{\sigma_\eta},$$
$$\underline{\alpha} = \tfrac{\sigma_T^2 - 4 \cdot \sigma_P^2 - \sqrt{(\sigma_T^2 - 12 \cdot \sigma_P^2) \cdot \sigma_T^2}}{2 \cdot (4 \cdot \sigma_P^2 + \sigma_T^2)}, \ \bar{\alpha} = \tfrac{\sigma_T^2 - 4 \cdot \sigma_P^2 + \sqrt{(\sigma_T^2 - 12 \cdot \sigma_P^2) \cdot \sigma_T^2}}{2 \cdot (4 \cdot \sigma_P^2 + \sigma_T^2)}.$$

A prerequisite for the existence of the interval $[\underline{\rho}, \bar{\rho}]$ is that $\sigma_T^2 > 12 \cdot \sigma_P^2$. For $\sigma_\theta^2 < \sigma_\eta^2$, we have $d\underline{\rho}/d\underline{\alpha}, d\bar{\rho}/d\bar{\alpha} > 0$ and:

$$\frac{d\underline{\alpha}}{d\sigma_T^2} = -\frac{(\sigma_T^2 - 12 \cdot \sigma_P^2) + 4 \cdot (\sigma_T^2 - \sqrt{(\sigma_T^2 - 12 \cdot \sigma_P^2) \cdot \sigma_T^2})}{(4 \cdot \sigma_P^2 + \sigma_T^2)^2 \cdot \sqrt{(\sigma_T^2 - 12 \cdot \sigma_P^2) \cdot \sigma_T^2}} \cdot \sigma_P^2 < 0, \tag{93}$$

$$\frac{d\bar{\alpha}}{d\sigma_T^2} = \frac{1}{2} \cdot \frac{8 + \frac{10 \cdot \sigma_T^2 - 24 \cdot \sigma_P^2}{\sqrt{(\sigma_T^2 - 12 \cdot \sigma_P^2) \cdot \sigma_T^2}}}{(4 \cdot \sigma_P^2 + \sigma_T^2)^2} \cdot \sigma_P^2 > 0. \tag{94}$$

As a consequence, $\underline{\rho}$ is decreasing and $\bar{\rho}$ is increasing in σ_T^2. Moreover:

$$\lim_{\sigma_T^2 \to \infty} \underline{\rho} = -\frac{\sigma_\theta}{\sigma_\eta} < 0, \ \lim_{\sigma_T^2 \to \infty} \bar{\rho} = \frac{\sigma_\eta^2 - 2 \cdot \sigma_\theta^2}{\sigma_\eta \cdot \sigma_\theta}, \ \lim_{\sigma_T^2 \to 12 \cdot \sigma_P^2} \underline{\rho} = \lim_{\sigma_T^2 \to 12 \cdot \sigma_P^2} \bar{\rho} = \frac{\sigma_\eta^2 - 5 \cdot \sigma_\theta^2}{4 \cdot \sigma_\eta \cdot \sigma_\theta}. \tag{95}$$

For $5 \cdot \sigma_\theta^2 < \sigma_\eta^2 < 25 \cdot \sigma_\theta^2$, we have $\lim_{\sigma_T^2 \to \infty} \bar{\rho} > 1$ and $0 < \lim_{\sigma_T^2 \to 12 \cdot \sigma_P^2} \underline{\rho} = \lim_{\sigma_T^2 \to 12 \cdot \sigma_P^2} \bar{\rho} < 1$, which completes the proof. □

Proof of Lemma 6

The proof is analogous to the proof of Proposition 1. □

Proof of Corollary 6

Rearranging equation (18) for the equilibrium ERC β_0 yields:

$$F_0 \equiv \left(\sum_{a \in A} \gamma^{(a0)2} \cdot \sigma_a^2 \right) \cdot \beta_0^3 + \sigma_v^2 \cdot (\beta_0 - 1) = 0. \tag{96}$$

Note that F_0 is increasing in β_0. Its slope depends on the sum $\sum_{s \in A} \gamma^{(s0)2} \cdot \sigma_s^2$. Raising the number of reporting users from $n+1$ to $n+2$ increases this sum by $\gamma^{(n+1,0)2} \cdot \sigma_{n+1}^2$. Similarly, $\sum_{s \in A} \gamma^{(s0)2} \cdot \sigma_s^2$ takes higher values if a reporting user $a \in A/\{0\}$ changes his objective such that the new objective is associated with higher (relative) uncertainty, $\gamma^{(a0)} = Var[\tilde{v}_a]/\sigma_v^2$. In both cases, equation (96) is satisfied by a lower level of β_0. □

Proof of Proposition 8

We use the implicit function theorem to show comparative static results of β_0 with regard to σ_M^2, $M \in \mathfrak{P}(A)$. Using the implicit characterization of β_0 according to (96), we can conclude that:

$$\frac{d\beta_0}{d\sigma_M^2} = -\frac{\partial F_0 / \partial \sigma_M^2}{\partial F_0 / \partial \beta_0} = \frac{\sum_{a \in A/M} 3 \cdot \gamma^{(a0)2} \cdot \sigma_a^2 + \sum_{a \in M} (3 \cdot \gamma^{(a0)} - 2) \cdot \gamma^{(a0)} \cdot \sigma_a^2}{\left(\sum_{a \in A} \gamma^{(a0)2} \cdot \sigma_a^2 \right) \cdot \sigma_v^2} \cdot \frac{(1 - \beta_0) \cdot \beta_0}{3 - 2 \cdot \beta_0}. \tag{97}$$

Because $\beta_0 < 1$, we can conclude that:

$$sgn\left(d\beta_0 / d\sigma_M^2 \right) = sgn\left(\sum_{a \in A/M} 3 \cdot \gamma^{(a0)2} \cdot \sigma_a^2 + \sum_{a \in M} (3 \cdot \gamma^{(a0)} - 2) \cdot \gamma^{(a0)} \cdot \sigma_a^2 \right). \tag{98}$$

This sign can only be negative if $\gamma^{(a0)} < 2/3$ for at least one $a \in M$, i.e., $A_M \neq \emptyset$. Then, the expression on the right-hand side becomes negative if and only if:

$$\sum_{a \in A_M} -(3 \cdot \gamma^{(a0)} - 2) \cdot \gamma^{(a0)} \cdot \sigma_a^2 > \sum_{a \in A/M} 3 \cdot \gamma^{(a0)2} \cdot \sigma_a^2 + \sum_{a \in M/A_M} (3 \cdot \gamma^{(a0)} - 2) \cdot \gamma^{(a0)} \cdot \sigma_a^2. \quad (99)$$

□

Chapter 2

Reporting Bias in Mergers & Acquisitions*

Abstract

I study an M&A transaction where a target firm is sold to a buyer. In a two-stage reporting game, the target manager reports firm value to the intermediary hired by the seller. The intermediary tries to undo the manager's bias and reports firm value to the buyer, thereby biasing its own report. The success fee paid to the intermediary is of particular interest to my analysis and affects the biasing incentives of the manager and the intermediary. I find that value relevance is always maximized for a success fee of zero. In this case, the intermediary reports his best estimate of firm value. Price efficiency, however, can be increasing or decreasing in success fee, depending on the relative uncertainty about biasing incentives of the manager and the intermediary. If there is uncertainty about both players' incentives, price efficiency is always maximized for an interior solution of success fee between zero and one.

Keywords: reporting bias, mergers and acquisitions, value relevance, price efficiency

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2.1 Introduction

There is vast evidence for earnings management and overpriced transactions in M&A, indicating low levels of price efficiency. For example, in December 1997, CUC International, Inc. and HFS, Inc. merged to Cendant. The merger became one of the largest accounting scandal at the time due to fraudulent earnings management activities by CUC. In the three years preceding the transaction, the company overstated earnings, thereby fooling auditors and the management of HFS. The fraud was only detected after the merger had been completed (Morgenson, 2004).

In the course of M&A, it is often the case that the transaction price is considered to be too high. When Microsoft Corporation paid USD 26.2 billion (or USD 196 per share) in an all-cash deal for the acquisition of LinkedIn, Inc. in 2016, it was considered a massive overpayment. Although Microsoft claimed that "the deal has massive synergies that will justify the purchase price" (Trainer, 2016), Morningstar, Inc. analysts valued LinkedIn at USD 155 per share, estimating an overpayment of more than 26 percent (Morningstar, 2016).

I aim to shed new theoretical light on the evidence. It is generally unclear what the reasons for low price efficiency and overpayment in M&A are. To this end, I study the consequences of misreporting incentives on reporting bias, value relevance and price efficiency where, in contrast to the existing literature, two parties can engage in earnings management. I analyze an M&A transaction where a seller represented by the manager sells his firm to a buyer, thereby hiring an intermediary such as an investment bank or consulting firm to conduct the transaction. In a two-stage reporting game, the target manager reports firm value to the intermediary who reports firm value to the buyer. The seller pays a success fee to the intermediary that is of particular interest to my analysis and affects biasing incentives of both, the manager and the intermediary.

I find that the buyer's reaction coefficient on the intermediary report as an indicator for value relevance is always maximized if the success fee arranged between the seller and the intermediary is zero. Because the intermediary has no incentive to bias the report in this case, he reports his best estimate of firm value to the buyer while trying to remove the manager's bias. However, that does not hold for price efficiency. If there is uncertainty about incentives of both, manager and intermediary, a small and positive success fee always increases price efficiency compared to a fee arrangement with zero success fee. Moreover, price efficiency for a success fee slightly below one is always higher than for a corner point success fee equal to one. This finding indicates that there always exists an interior solution of success fee between zero and one that maximizes price efficiency. Furthermore, my model shows that a higher synergy importance always implies a higher value relevance (and price efficiency), predicting that a buyer with higher interest in synergies would place more weight on the intermediary report when pricing the firm.

The contribution of this paper is twofold. It adds new insights to the research in M&A and the literature on earnings management. Thus far, earnings management in an M&A context has not been studied from a theoretical point of view. This paper addresses the gap between empirical evidence for earnings management in M&A transactions and the missing theoretical basis.

So far, no one has studied the joint possibility of manipulation by both, the firm seller and intermediary in the context of an M&A transaction as I do in this paper. However, there exist theoretical papers on M&A which are specified below.

In their model, Shleifer and Vishny (2003) provide a theoretical intuition for earnings manipulation in M&A, especially for overvaluation purposes of buyer equity in the context of stock for stock deals. Similarly, Fischer and Louis (2008) study managers' financial reporting behavior prior to management buyouts (MBOs). They argue that managers not only have an incentive to manage earnings downward to reduce the purchase price in the context of MBOs, but also an incentive for upward earnings management in order to reduce financing costs when they use external funds for the acquisition.

French and McCormick (1984) explain in their sealed-bid auction study that "the owner has an incentive to provide optimistic information about the value of the asset", providing a rationale for target earnings management. Hietala, Kaplan, and Robinson (2003) argue that, besides uncertainty about firm value, managerial overconfidence and following Jensen and Meckling (1976), private benefits from acquisitions are two additional reasons for overpayment in M&A. Gärtner and Schmutzler (2009) study a merger of two privately informed parties. In a mechanism-design model, they analyze the effects of the parties' information endowment about stand-alone values and merger profits and describe conditions for efficient merger decisions. However, they restrict their analysis on truthful reporting, i.e., any kind of misreporting is ignored.

This paper also adds to the analytical earnings management literature. The model of Stein (1989) assumes that the managerial incentives are known such that earnings management activities of can be backed out perfectly. Fischer and Verrecchia (2000) show that if there is uncertainty about the incentives of the manager, the capital market backs out the reporting bias only in expectation. In this setting, the manager can benefit from misreporting earnings. Dye and Sridhar (2004) study relevance and reliability trade offs in accounting reports under the assumption that accounting reports aggregate precise, but potentially biased managerial information and unmanipulable, but imprecise information on a firm's cash flow. The former type of information is more relevant due to its precision but less reliable because of the manager's bias. In contrast to Fischer and Verrecchia (2000), they introduce reporting noise by assuming uncertainty about managers' costs of misreporting which leads to similar results. In their reporting game, Ewert and Wagenhofer (2005) study the tightness of accounting standards when managers can engage in both, accounting and real earnings management. Accounting quality is increased by tighter standards through lower accounting earnings management while real earnings management is increasing. It can be the case that the total reporting bias is higher compared to the situation with looser standards. Caskey, Nagar, and Petacchi (2010) analyze a two-stage reporting model where a manager reports earnings to an auditor who tries to back out the managerial bias, but then adds an own bias and reports biased earnings to the public. They find that total reporting bias can be increasing in managers' costs of misreporting.

Compared to theoretical research in M&A, there is vast empirical literature, especially studies of earnings management in M&A transactions.

Easterwood (1998) find that target managers systematically increase reported earnings in the quarters preceding the takeover. Chang and Lim (2017) find that the financial reporting quality of target firms is lower than that of non-target firms due to earnings management activities prior to M&A. Campa and Hajbaba (2016) find evidence for real earnings management among targets of cash acquisitions and subsequent underperformance of the target firm due to the reversal of real earnings management. In similar contexts, Teoh, Welch, and Wong (1998b) who study initial public offerings as well as Teoh, Welch, and Wong (1998a) and Kothari, Mizik, and Roychowdhury (2016) analyzing seasoned equity offerings find evidence for earnings management to increase transaction price. However, Anagnostopoulou and Tsekrekos (2013) find that targets seeking a buyer manage earnings downward and discuss a lower acquisition price increasing deal probability as a potential explanation for such behavior. In stock for stock mergers, acquiring firms manipulate their accounting reports by overstating their earnings before the merger announcements to increase the stock price in order to reduce the acquiring costs (see Erickson and Wang, 1999; Louis, 2004; Botsari and Meeks, 2008). Bens, Goodman, and Neamtiu (2012) find that buyer firms facing performance pressure after deal completion to justify the transaction engage in earnings management. Many papers find evidence for overpayments in M&A, often measured by value destruction through a decreasing share price of the buyer in the aftermath of the transaction (Wruck, 2001; John, Liu, and Taffler, 2010; Díaz, Azofra, and Gutiérrez, 2013).

The remainder of this paper is structured as follows: In Section 2.2, I present the model setup. The equilibrium properties are derived in Section 2.3 and benchmark cases are analyzed in Section 2.4. Section 2.5 provides the main results of the paper, in particular the consequences of biasing incentives on value relevance and price efficiency. Section 2.6 summarizes the findings in this paper and concludes.

2.2 Model setup

I consider a typical M&A transaction where a target firm is sold by a seller (the owner of the firm) to a buyer. The seller is represented by a target manager who hires an intermediary to conduct the sale of the target firm. The intermediary could be an investment bank or an M&A consulting firm.

The total firm value $\tilde{v}$ from the buyer's perspective is the weighted sum of two normally distributed random components:

$$\tilde{v} = \tilde{\eta} + \gamma \cdot \tilde{s}. \tag{1}$$

The first component $\tilde{\eta} \sim N(0, \sigma_\eta^2)$ represents the stand-alone firm value of the target firm. I refer to this component as the *asset value* of the target. The second component $\tilde{s} \sim N(0, \sigma_s^2)$ is the *synergy value* that is realized during the transaction. The parameter $\gamma > 0$ indicates the relative importance of the synergy value to the buyer. All players share common prior beliefs about the distribution of the two firm value components.[1] I further assume that the asset value and the synergy value are stochastically independent and uncorrelated which implies that the covariance of $\tilde{\eta}$ and $\tilde{s}$ is zero.[2] Thus, the firm value $\tilde{v}$ is normally distributed with mean $\mu_v = 0$ and variance $\sigma_v^2 = \sigma_\eta^2 + \gamma^2 \cdot \sigma_s^2$.

As in a single-firm, single-period reporting game, the manager reports total firm value after observing a private signal of the stand-alone target value to the intermediary. However, unlike the standard reporting game, there are two reports in my model. That is, in addition to the manager's report, the intermediary observes a private signal of the synergy value, updates his belief about the true firm value and reports to the buyer. The buyer sets the final transaction price by using the report of the intermediary.[3]

Before issuing her report to the intermediary, the manager privately observes the firm's accounting earnings e as an imprecise measure of the asset value $\tilde{\eta}$ with noise $\tilde{\varepsilon}_e \sim N(0, \sigma_e^2)$:

$$\tilde{e} = \tilde{\eta} + \tilde{\varepsilon}_e. \tag{2}$$

The true earnings can be understood as internal information which are not publicly observable, for example derived from a managerial accounting system. The manager updates her belief about the total firm value by using the private earnings signal and the prior belief about the synergy value. She then adds a bias and issues the report r_m to the intermediary. The manager's report is not observed by the buyer. At the same time, the intermediary observes a private signal of the synergy value $\tilde{s}$ which contains a noise $\tilde{\varepsilon}_z \sim N(0, \sigma_z^2)$:

$$\tilde{z} = \tilde{s} + \tilde{\varepsilon}_z. \tag{3}$$

The intermediary's signal arises from market research, industry knowledge and experience from past transactions.[4] The variance of the measurement error σ_z^2 can be interpreted as an indication of the intermediary's quality. After observing the manager's report

[1] Without qualitatively changing the results, the expected asset value and the expected synergy value are set to zero.

[2] I acknowledge that the acquisition of larger firms might result in positive synergy values, e.g., in the form of market entries (positive correlation) or in negative synergy values, e.g., more complex integration of the target administration (negative correlation). However, allowing for a non-zero correlation does not qualitatively change the results of this paper.

[3] I assume that the transaction takes place for sure and that only the transaction price must be determined.

[4] The intermediary's signal is assumed to be exogenously given.

r_m and the synergy signal z, the intermediary updates his estimation of the total firm value considering his conjectures about the manager's bias. Finally, the intermediary reports r_i, including the intermediary's own bias, to the buyer.

In choosing their optimal bias levels, the manager and the intermediary aim to maximize their expected utility. As usual in M&A transactions, the intermediary's proceeds contain a fixed retainer fee to cover the costs and a success fee depending on the transaction price P. For simplicity and without changing the results, the retainer fee is normalized to zero. The success fee is defined as a share $\delta \in [0, 1]$ of the target firm's price. The magnitude of this share represents the relative bargaining power of the intermediary to the target firm who retains a share of $1 - \delta$ of the transaction price. I assume that these shares are exogenously given and fixed before the parties enter the transaction.[5]

The expected utility of the manager is given by:

$$E[U_m] = x_m \cdot (1 - \delta) \cdot E[\hat{P}|e] - \frac{1}{2} \cdot E[(\tilde{v} - r_m)^2|e]. \tag{4}$$

The manager's utility depends on the seller's share of the transaction volume after deducting the intermediary's success fee. The incentive weight of the manager x_m represents her given explicit (*monetary*) and implicit (*reputational*) interest in a high transaction price. Besides the manager's current equity stake held in form of restricted shares and options, the manager's incentives can arise also from different forms of side payments to the target manager, e.g., golden parachutes in form of stock options, unscheduled stock options during M&A negotiations or retention agreements such as golden handcuffs. The purpose of the incentive systems is to counter managerial resistance during the takeover process and to attain the highest possible price (see Berkovitch and Israel, 1996; Fluck and Lynch, 1999; Hartzell, Ofek, and Yermack, 2004; Broughman, 2017). Furthermore, the manager can be interested in a high transaction price through reputational incentives of being associated with a valuable and prestigious firm Srinivasan (2005). Following Fischer and Verrecchia (2000), I assume here the manager's incentive rate is a normally distributed random variable with $\tilde{x}_m \sim N(\mu_m, \sigma_m^2)$ from the perspective of third parties and

[5] This is the standard procedure in practice. Before an M&A project begins, negotiations take place between the seller and the intermediary regarding the contractual terms of the sale mandate where the fee arrangement is defined. More generally, the players' shares in the transaction price can be thought of as the solution of a generalized Nash bargaining game (see Nash Jr., 1950). Modeling this game is beyond the scope of this study.

privately observed by the manager before issuing her report to the intermediary.

On the other hand, the intermediary's expected utility function takes the form:

$$E[U_i] = x_i \cdot \delta \cdot E[\hat{P}|r_m, z] - \frac{1}{2} \cdot E[(\tilde{v} - r_i)^2|r_m, z]. \tag{5}$$

Similar to the manager, the intermediary is also interested in the magnitude of the transaction price. The higher the transaction price, the higher is the success fee paid to the intermediary. In the following analysis, the intermediary is represented by a single investment banker or consultant. So that the incentive rate x_i of the intermediary can be thought of as a bonus rate (*monetary* incentive) or a gain in *reputation* for working on a large project in terms of deal size (Knee, 2006). Similarly as for the manager, I assume the intermediary's incentive rate to be normally distributed with $\tilde{x}_i \sim N(\mu_i, \sigma_i^2)$.

It is important to understand that the misreporting in this model takes the form of accounting earnings management or window dressing without bearing any real consequences for the firm value. Earnings management in this sense involves the selection of accounting procedures in line with generally accepted accounting principles. Real earnings management would have an impact on the firm value and thus a single-period analysis would not be sufficient to study such a setting.[6] As common in the earnings management literature, I assume a quadratic cost function for both, the manager and the intermediary, each function calibrated with one half (e.g., Fischer and Verrecchia, 2000; Dye and Sridhar, 2004; Ewert and Wagenhofer, 2005; Guttman, Kadan, and Kandel, 2006; Feller and Schäfer, 2019). I follow Caskey, Nagar, and Petacchi (2010) in assuming that the misreporting costs are proportional to the difference between the expected firm value and the respective report conditional on the information observed by the respective player.

The buyer only observes the intermediary's report about the total firm value. Thus, the price P is defined as the expected firm value conditional on the intermediary's report r_i:

$$P = E\left[\tilde{v}|r_i\right]. \tag{6}$$

The timeline of my model unfolds as follows. First, the manager and the intermediary privately observe their incentive rates x_m and x_i as well as the realizations of the earnings signal e (only the manager) and the synergy signal z (only the intermediary). Then the

[6] For an example of a model with real earnings management see Ewert and Wagenhofer (2005).

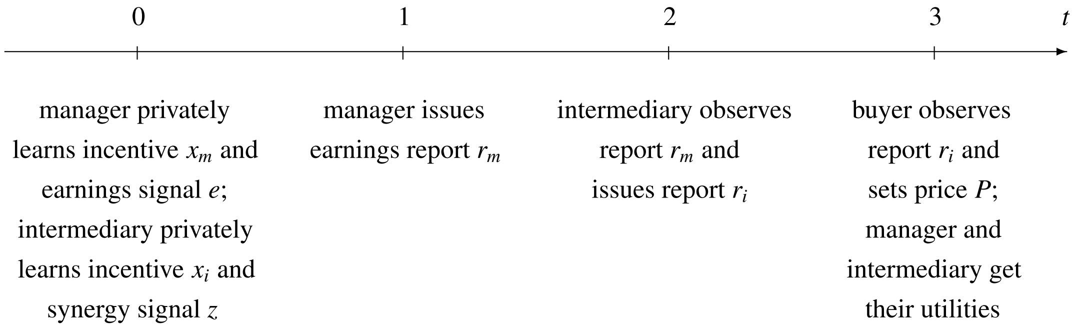

Figure 1 *Timeline*

manager issues the earnings report r_m to the intermediary.[7] After observing the report r_m, the intermediary provides the report r_i to the buyer. Finally, the buyer sets the transaction price based on the intermediary's report. The manager and the intermediary receive their respective utilities. The timeline of the model is summarized in Figure 1.

2.3 Equilibrium

I analyze a linear rational expectations equilibrium where the manager's and the intermediary's reporting function as well as the buyer's pricing function take the following forms:[8]

$$r_m = \underbrace{E[\tilde{v}|e]}_{\text{firm value belief}} + \underbrace{\lambda_0 + \lambda_e \cdot e + \lambda_x \cdot x_m}_{\text{manager's reporting bias}}, \tag{7}$$

$$r_i = \underbrace{E[\tilde{v}|r_m, z]}_{\text{firm value belief}} + \underbrace{\omega_0 + \omega_r \cdot r_m + \omega_z \cdot z + \omega_x \cdot x_i}_{\text{intermediary's reporting bias}}, \tag{8}$$

$$P(r_i) = \alpha + \beta \cdot r_i. \tag{9}$$

[7] The buyer does not observe the earnings report.

[8] I follow Caskey, Nagar, and Petacchi (2010) by integrating their conditional expectations of the firm value in the players' conjectures.

The manager updates her belief about total firm value after observing her private signal of the asset value and adds her bias based on the private information e and x_m when reporting r_m to the intermediary. The intermediary then updates his belief of the total firm value after observing the manager's report r_m as well as his private signal of the synergy value z, anticipating the manager's bias. Then the intermediary adds his own bias to the report r_i which is addressed to the buyer, depending on his information set r_m, z and x_i. Finally, the buyer sets the price after observing r_i where β is the weight put on the intermediary's report when pricing the firm. Lemma 1 summarizes the equilibrium of the model.

Lemma 1 *In the reporting game, there is a unique linear equilibrium that takes the form:*

$$\lambda_0 = \lambda_e = 0 \ \ and \ \ \lambda_x = (1-\delta)\cdot\beta\cdot\frac{Cov[\tilde{v},\tilde{r}_m]}{Var[\tilde{r}_m]}, \tag{10}$$

$$\omega_0 = \omega_r = \omega_z = 0 \ \ and \ \ \omega_x = \delta\cdot\beta, \tag{11}$$

$$\alpha = -\delta\cdot\mu_i\cdot\beta^2 \ \ and \ \ \beta = \frac{Var\,[E[\tilde{v}|r_m,z]]}{Var\,[E[\tilde{v}|r_m,z]] + \omega_x^2\cdot\sigma_i^2}. \tag{12}$$

I refer to λ_x, ω_x and β as reaction coefficients since those coefficients directly affect the players' optimal strategies. Further, λ_x and ω_x are interpreted as biasing coefficients of the manager and the intermediary, respectively:

$$\lambda_x = \frac{\partial r_m}{\partial x_m} \ \ \text{and} \ \ \omega_x = \frac{\partial r_i}{\partial x_i}. \tag{13}$$

These coefficients are an indicator of the manager's and the intermediary's marginal incentives to bias their respective reports for a given change in the realization of their unknown preference parameter. Therefore, λ_x and ω_x measure the magnitude of the seller's and the buyer's reporting biases, respectively: The higher λ_x and ω_x, ceteris paribus, the higher is the individual reporting bias for a given realization of x_m and x_i, respectively.

Corollary 1 *The equilibrium reaction coefficients take values from the following bounded intervals:*

a) *The reaction coefficient of the manager's reporting function with regard to the magnitude of her private incentive rate x_m is bounded as follows: $\lambda_x \in (0,(1-\delta)\cdot\beta)$.*

b) *The reaction coefficient of the intermediary's reporting function with regard to the magnitude of his private incentive rate x_i is bounded as follows: $\omega_x \in (0,\delta\cdot\beta)$.*

c) *The buyer's reaction coefficient with regard to the intermediary's report r_i is bounded as follows:* $\beta \in (0, 1)$.

It is important to note that these coefficient boundaries only hold for non-benchmark cases, i.e., when $\delta \in (0, 1)$.

As usual in the class of reporting games considered in this paper, the players' biases do not depend on their own signal realizations, i.e., $\lambda_e = 0$ and $\omega_r = \omega_z = 0$. However, the manager and the intermediary use their signals to update their belief about true total firm value.

For the purpose of analyzing the equilibrium properties in the sense of market efficiency, two different measures are used: *value relevance* and *price efficiency*. In most one-stage reporting games (e.g., Fischer and Verrecchia (2000); Feller and Schäfer (2019)), the two measures coincide. However, this relationship does not hold in two-stage reporting games and therefore requires a careful analysis.

The value relevance describes the association between the intermediary's report r_i and the final takeover offer P, i.e., how much the buyer relies on the provided information when pricing the firm. Consequently, the buyer's reaction coefficient β represents the value relevance of the intermediary's report:

$$\beta = \frac{\partial P}{\partial r_i} = \frac{Cov\left[\tilde{v}, \tilde{r}_i\right]}{Var\left[\tilde{r}_i\right]}. \tag{14}$$

The second measure, price efficiency, sheds light on how much information about the true firm value is contained in the transaction price P, i.e., to what degree the initial buyer's uncertainty about the firm value is reduced. The price efficiency PE is defined as the relative portion of prior firm value variance that is eliminated by the information contained in the transaction price:

$$PE = \frac{Var\left[\tilde{v}\right] - Var\left[\tilde{v}|P\right]}{Var\left[\tilde{v}\right]} = \beta \cdot \frac{Cov\left[\tilde{v}, \tilde{r}_i\right]}{Var\left[\tilde{v}\right]}, \quad \text{where } PE \in [0, 1]. \tag{15}$$

If the transaction price is perfectly revealing the firm value, i.e., $Var\left[\tilde{v}|P\right] = 0$, price efficiency is maximized ($PE = 1$) and the buyer pays the true firm value. On the other hand, if the price is not informative at all, i.e., $Var\left[\tilde{v}|P\right] = Var\left[\tilde{v}\right]$, price efficiency is lowest ($PE = 0$) and nothing about the true firm value is learned by the transaction price. In most financial reporting studies, the manager reports earnings to the stock market which in turn sets the share price. Price efficiency shows how much information about the fundamental firm value is captured in the share price, i.e., the extent to which the market correctly prices the firm. In this paper, price efficiency is an indicator of whether a correct transaction price is paid.

2.4 Benchmark analysis

In this subsection, I analyze two benchmark cases. First, I study the results of the model in the case where the success fee δ is fixed at zero, the *lower benchmark*. Second, I consider the case in which δ is equal to one, the *upper benchmark*.

Lower benchmark: zero success fee

A success fee of zero means that the intermediary's proceeds only consist of a fixed retainer fee[9] and do not depend on the transaction price. With this reward structure, the seller receives the entire transaction price. The equilibrium properties of the benchmark case follow directly from Lemma 1 and are presented in Corollary 2.

Corollary 2 *The following unique equilibrium properties exist in the benchmark case with zero success fee:*

$$\lambda_0 = \lambda_e = 0 \;\; and \;\; \lambda_x = \frac{Cov[\tilde{v}, \tilde{r}_m]}{Var[\tilde{r}_m]}, \tag{16}$$

$$\omega_0 = \omega_r = \omega_z = \omega_x = 0, \tag{17}$$

$$\alpha = 0 \;\; and \;\; \beta = 1. \tag{18}$$

Compared to the equilibrium reaction coefficients in Lemma 1, the manager's biasing coefficient λ_x and the buyer's pricing coefficient β reach their maximum values in the benchmark case. On the other hand, the biasing coefficient of the intermediary, ω_x, is equal to zero and thus strictly lower than in the case with a positive success fee rate δ.

[9] As described before, the retainer fee is normalized to zero in this paper.

In the lower benchmark, the manager's bias is strictly higher than in a case with a positive success fee where a lower portion of the transaction proceeds is assigned to the seller. While the manager has maximum incentive to bias, the intermediary has no incentive to misreport the firm value to the buyer because his payoff does not depend on the price offered by the buyer. Consider the intermediary's utility function (5). With a success fee of zero, i.e., $\delta = 0$, the intermediary maximizes his utility by minimizing the difference between his report and the updated belief about firm value. As a result, the intermediary reports his best possible estimation of total firm value given his private information and considering the information contained in the manager's biased earnings report. In minimizing the personal costs of misreporting, the intermediary acts exactly in the buyer's interest, i.e., there is no conflict of interest. Compared to the buyer, the intermediary has more precise information about the firm value after observing r_m[10] and z. Therefore, the buyer relies entirely on the intermediary's report when pricing the firm: β equals one and value relevance is maximized. Consequently, α, the correction for the managerial bias, is zero.

Furthermore, the manager's biasing incentive λ_x reaches its maximum magnitude, ceteris paribus, for a success fee δ of zero. The findings regarding biasing incentives and value relevance are described in Corollary 3.

Corollary 3 *The manager's biasing incentive and value relevance are maximized in the benchmark case of a zero success fee while the intermediary has no incentive to bias and reports his best estimate of the firm value.*

Upper benchmark: maximum success fee

In the opposite extreme compared to the lower benchmark analyzed before, the intermediary has the entire bargaining power. Thus, the intermediary receives the total transaction price since δ is equal to one in this case. The equilibrium properties follow from Lemma 1 and are presented in Corollary 4.

[10] It is important to note that the manager's report r_m is not observed by the buyer.

Corollary 4 *The following unique equilibrium properties exist in the upper benchmark with a success fee of one:*

$$\lambda_0 = \lambda_e = \lambda_x = 0, \tag{19}$$

$$\omega_0 = \omega_r = \omega_z = 0 \ \ and \ \ \omega_x = \beta, \tag{20}$$

$$\alpha = -\mu_i \cdot \beta^2 \ \ and \ \ \beta = \frac{Var\left[E[\tilde{v}|r_m, z]\right]}{Var\left[E[\tilde{v}|r_m, z]\right] + \beta^2 \cdot \sigma_i^2}. \tag{21}$$

The resulting biasing coefficients show that the manager has no incentive to manipulate the earnings report in the benchmark case of maximum success fee. The intuition is the same as above: Because the manager's payoff does not depend on the transaction price P, she would only suffer misreporting costs without benefiting from a higher price. On the other hand, the intermediary's incentive to bias, ω_x, is strictly higher than in the lower benchmark case. Furthermore, α is non-zero. The intuition is straightforward: The buyer knows that the intermediary biases the report and thus corrects for the expected bias when setting the transaction price. Compared to the lower benchmark, value relevance is strictly lower in the case of $\delta = 1$. The findings regarding biasing incentives and value relevance are described in Corollary 5.

Corollary 5 *The intermediary's biasing incentive is maximized in the benchmark case of maximum success fee. The value relevance for* $\delta = 1$ *is strictly lower than the value relevance for* $\delta = 0$*, i.e.,* $\beta\big|_{\delta=1} < \beta\big|_{\delta=0}$.

2.5 Main results

This section studies selected comparative statics of the model and sheds light on value relevance and price efficiency in M&A transactions for arbitrary success fees between zero and one.

Comparative statics and value relevance

Corollary 6 summarizes comparative statics of the reaction coefficient β and the biasing coefficients λ_x and ω_x with respect to success fee δ and synergy importance γ.

Corollary 6 *Comparative statics:*
a) Buyer's reaction coefficient β:

$$\frac{\partial\beta}{\partial\delta} \gtrless 0, \quad \frac{\partial\beta}{\partial\gamma} > 0. \tag{22}$$

b) Manager's biasing coefficient λ_x:

$$\frac{\partial\lambda_x}{\partial\delta} < 0, \quad \frac{\partial\lambda_x}{\partial\gamma} > 0. \tag{23}$$

c) Intermediary's biasing coefficient ω_x:

$$\frac{\partial\omega_x}{\partial\delta}, \frac{\partial\omega_x}{\partial\gamma} > 0. \tag{24}$$

As described in Corollary 6, the manager's incentive to bias is decreasing in the success fee, i.e., the lower the seller's share of the transaction price, the less the manager is willing to bias the report to influence the price. In contrast, the intermediary's incentive to bias his report is increasing in δ. The higher the intermediary's share of the transaction price, the more he benefits from a higher price and thus tries to increase it by manipulating his report. Figure 2 shows the relation of an increasing success fee δ within the defined range of $[0, 1]$ and the biasing incentives of the manager, λ_x, and the intermediary, ω_x.

I study next the relation between the success fee and value relevance. As outlined in Corollary 6, the effect of the success fee δ on the buyer's reaction coefficient β, a proxy for value relevance, is ambiguous. Although value relevance is decreasing in success fee for most cases, there are settings in which value relevance is increasing again when the parameter δ gets closer to its upper bound of one.

The reason for this ambiguous effect is not obvious and requires further analysis of the first-order derivative $d\beta/d\delta$. According to the equilibrium definition, the coefficient β is directly affected by the success fee δ, but also indirectly via λ_x. Therefore, varying the parameter value of δ has a direct effect and an indirect effect on value relevance as described in Corollary 7.

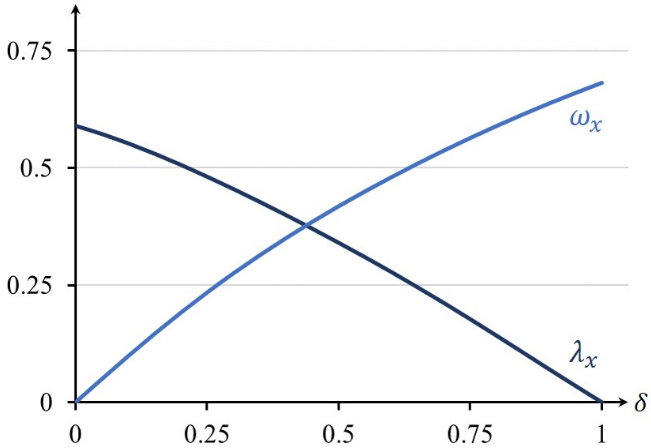

Figure 2 *The effect of success fee on biasing incentives*
($\sigma_\eta^2 = \sigma_e^2 = \sigma_s^2 = \sigma_z^2 = \sigma_m^2 = \sigma_i^2 = 2$, $\gamma = 1$)

Corollary 7 *An increasing success fee δ has a direct effect (D_β) and an indirect effect (I_β) on value relevance β with opposite signs:*

$$\frac{d\beta}{d\delta} = \underbrace{\frac{\partial\beta}{\partial\delta}}_{D_\beta\,<\,0} + \underbrace{\underbrace{\frac{\partial\beta}{\partial\lambda_x}}_{<\,0} \cdot \underbrace{\frac{\partial\lambda_x}{\partial\delta}}_{<\,0}}_{I_\beta\,>\,0}. \tag{25}$$

The direct effect D_β represents the change of β implied by a marginal increase of success fee δ if the manager's biasing coefficient λ_x is held constant. An increasing success fee increases the intermediary's incentive to bias. The buyer anticipates that and relies less on the intermediary report when pricing the firm, value relevance decreases. On the other hand, the indirect effect I_β takes into account that value relevance is also affected by the manager's reaction following a change in success fee. An increasing success fee lowers the manager's incentive to bias what in turn increases the buyer's reaction coefficient.

For most cases, the direct effect dominates the indirect effect, i.e., value relevance is decreasing in success fee. For the lower benchmark of zero success fee as the starting point, an increasing success fee leads always to a decreasing value relevance as the direct effect dominates. However, for success fee values closer to one, the direct effect does not necessarily dominate the indirect effect anymore.

The cases where value relevance is increasing in success fee are characterized by a significantly higher uncertainty about managerial reporting incentives, i.e., σ_m^2 compared to the uncertainty about the reporting incentives of the intermediary combined with a relatively high success fee close to one. Thereby, the success fee serves as a balancing tool of how much uncertainty in the intermediary report is due to managerial bias and how much is due to intermediary bias.

In the lower benchmark case of a zero success fee, the intermediary has no incentive to bias and all of the report uncertainty is driven by managerial bias which the intermediary tries to remove and value relevance is maximized. However, it is important to understand that the intermediary does not know the incentive rate of the manager. Therefore, the intermediary cannot remove all of the managerial bias when updating his belief about firm value. For a small, but positive success fee, the intermediary starts biasing as well, therefore adding noise to the report and value relevance is decreasing. In the intermediate range of success fee, the buyer cannot distinguish to what extent the report uncertainty is due to the manager and to what extent due to the intermediary such that information content and therefore value relevance is further decreasing.

As described before, for a low success fee, most of the report uncertainty is due to the manager's bias and the uncertainty about her incentives. The higher the success fee, the higher is the share in total uncertainty that stems from intermediary activities as the manager has less incentives to bias anymore and λ_x approaches zero (see Lemma 1). Even though the intermediary biases more in case of a higher success fee, the buyer learns more from the intermediary report due to lower managerial biasing. If the success fee is close to one and if uncertainty about intermediary incentives is relatively low compared to the manager, value relevance is increasing in success fee as a higher weight is shifted on the intermediary, reducing overall uncertainty of the report because the indirect effect outweighs the direct effect.

Proposition 1 summarizes the findings and provides a condition for a positive relation of success fee and value relevance.

Proposition 1 *Value relevance can be increasing in success fee for certain parameter settings:*

a) *For success fee values close to zero and if uncertainty about the incentives of the intermediary is non-zero, i.e.,* $\sigma_i^2 > 0$*, value relevance is always decreasing in the success fee.*

b) *For larger success fee values and if the uncertainty about managerial incentives is sufficiently high compared to the uncertainty about the incentives of the intermediary, value relevance is increasing in success fee if the following condition holds true:*[11]

$$\frac{1-\beta}{\beta^2} \cdot \frac{\lambda_x \cdot \Sigma \cdot \Omega}{\Sigma + \lambda_x^2 \cdot \sigma_m^2} > \delta \cdot \sigma_i^2 \cdot \Delta. \tag{26}$$

Figure 3 illustrates the general case of a decreasing value relevance ($\sigma_m^2 = 2$) and an example in which value relevance is increasing in success fee for values close to one ($\sigma_m^2 = 800$).

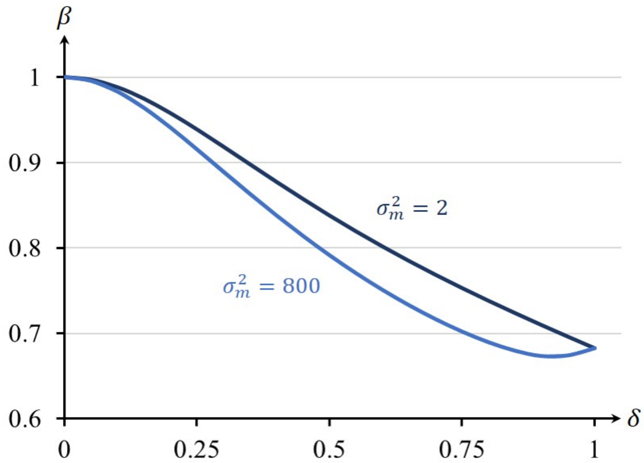

Figure 3 *The effect of success fee on value relevance*
$(\sigma_\eta^2 = \sigma_e^2 = \sigma_s^2 = \sigma_z^2 = \sigma_i^2 = 2, \gamma = 1)$

The analysis of comparative statics shows that the buyer's reaction coefficient β and both biasing incentives, λ_x and ω_x, are increasing in the synergy importance parameter γ. Figure 4 shows this relation graphically.

[11] Note that $\Sigma = \frac{\sigma_\eta^4}{\sigma_\eta^2+\sigma_e^2}$, $\Omega = \frac{\Sigma^2}{\Sigma+\lambda_x^2 \cdot \sigma_m^2}$ and $\Delta = 3 \cdot \lambda_x^2 + \frac{\Sigma}{\sigma_m^2}$.

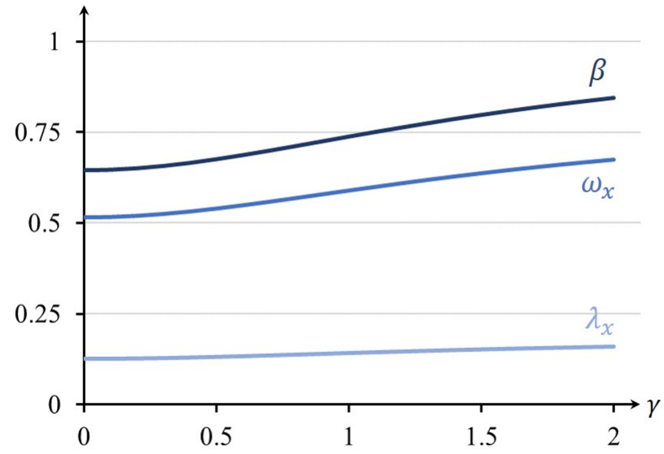

Figure 4 *The effect of synergy importance on value relevance and biasing incentives* $(\sigma_\eta^2 = \sigma_e^2 = \sigma_s^2 = \sigma_z^2 = \sigma_m^2 = \sigma_i^2 = 2,\ \delta = 0.8)$

The intuition behind this result lies in the information content of the intermediary's report from the buyer's perspective. A higher parameter value γ means that the buyer assigns a higher weight to the synergy value when estimating total firm value and pricing the firm. The intermediary conveys information about synergy value when reporting to the buyer. Thus, a higher synergy importance γ means that the buyer learns more about firm value from the intermediary's report due to a higher information content of the report. As a consequence, the buyer puts more weight on the intermediary report when pricing the target firm, i.e., the reaction coefficient β increases. On the other hand, the positive correlation between the synergy importance γ and β has a direct effect on the biasing coefficients of the manager and the intermediary. They anticipate that a higher interest in synergy value leads to a higher reaction of the buyer and this effect increases the biasing incentives of both players. Consequently, reporting bias is increasing in synergy importance γ for both, the manager and the intermediary. Proposition 2 describes the relation between value relevance and synergy importance.

Proposition 2 *Value relevance is always increasing in synergy importance.*

The relation between price efficiency and synergy importance is driven by the positive correlation of value relevance and synergy importance. Therefore, no additional analysis regarding price efficiency and synergy importance is made as the results are straightforward.

The paper focuses in the analysis on the success fee δ and the synergy importance γ. However, the results from Fischer and Verrecchia (2000) hold in this model, i.e., the buyer's reaction coefficient β as a proxy for value relevance is increasing in value uncertainty $(\sigma_\eta^2, \sigma_s^2)$, but decreasing in signal noise and incentive uncertainty $(\sigma_e^2, \sigma_z^2, \sigma_m^2, \sigma_i^2)$. The intuition for these results builds on the intermediary report's information content for the buyer when determining the transaction price. The lower the uncertainty of the intermediary report, the higher is the information content to the buyer and therefore the buyer's reaction coefficient β.[12]

The negative relation between value relevance and the variance of the intermediary's synergy signal σ_z^2 suggests that value relevance is always higher if the intermediary hired by the target is of high quality. On that note, this result serves as a possible explanation for the empirical finding of high success fees paid to high quality investment banks (see Rau, 2000; Hunter and Jagtiani, 2003; Walter, Yawson, and Yeung, 2008).

Price efficiency

In this section, I analyze the relation between success fee and price efficiency. As described before, price efficiency in the model's context of M&A transactions can be interpreted as a proxy for the difference between the true value of the target firm including synergies and the transaction price. The higher the price efficiency, the smaller is the difference between the true value and the price. The lower the price efficiency, the higher is the possibility that the buyer over- or underpays. According to Goold and Campbell (1998), even synergy-producing transactions are prone to overpayments. Due to the assumption of normal distributions of random variables, the possibility is equally high for over- and underpayment, respectively. This interpretation is feasible because it is assumed that the buyer is taking into account the synergy value of the target firm when setting the price.[13]

[12] For a detailed explanation of the intuition see Fischer and Verrecchia (2000) and Feller and Schäfer (2019).

[13] A difference between the assets of the target, i.e., the book value, and the transaction price can be an indicator for the target's synergy value to the buyer. This difference, however, has nothing to do with price efficiency.

In order to study price efficiency, I first define the derivative of price efficiency with respect to success fee. Similar to the analysis of value relevance, Corollary 8 shows that the effect of success fee on price efficiency is a priori ambiguous.

Corollary 8 *An increasing success fee δ impacts price efficiency via two simultaneous effects:*[14]

$$\frac{dPE}{d\delta} = \underbrace{\frac{\partial \beta}{\partial \delta} \cdot \Gamma}_{E_\beta \gtrless 0} + \underbrace{\beta \cdot \underbrace{\frac{\partial \Gamma}{\partial \lambda_x}}_{<0} \cdot \underbrace{\frac{\partial \lambda_x}{\partial \delta}}_{<0}}_{E_\lambda > 0} . \tag{27}$$

On one hand, price efficiency is affected by success fee via the change in the buyer's reaction coefficient induced by a change in δ, E_β. As shown before, the reaction of value relevance to a changing success fee is ambiguous, but in most cases β is decreasing in δ. The reason is that an increasing success fee provides the intermediary with higher incentives to bias the report. This leads to a lower information content due to an increasing variance and thus to a lower price efficiency. On the other hand, the term Γ is always increasing in δ such that E_λ is positive. This follows directly from the negative relation between the manager's biasing coefficient λ_x and the success fee. A higher success fee implies a lower interest in the transaction price on the manager's side. Hence, the manager biases less and the overall report becomes more informative as the cumulative uncertainty about managerial incentives decreases. Consequently, price efficiency increases in success fee.

Further analysis of price efficiency requires a closer look at the uncertainty about manager and intermediary incentives, i.e., σ_m^2 and σ_i^2, as they drive the information content of the intermediary report r_i and therefore price efficiency. The success fee serves as a balancing tool and determines how much of the total uncertainty in the report is due to the uncertainty about manager's biasing incentives (*low success fee*) and how much of it is due to the uncertainty about intermediary's biasing incentives (*high success fee*). In order to analyze the interplay of incentive uncertainty of the manager and the intermediary, i.e., σ_m^2 and σ_i^2, I study the impact of success fee on value relevance and price efficiency for isolated incentive parameters.

[14] Where $\Gamma = \dfrac{Cov\,[\tilde{v}, \tilde{r}_i]}{Var\,[\tilde{v}]}$.

First, I look at the case when there is no uncertainty about managerial biasing incentives, that is when $\sigma_m^2 = 0$. In that case, value relevance β and price efficiency PE are of the following form in equilibrium:

$$\beta\Big|_{\sigma_m^2=0} = \frac{\Sigma + \Psi}{\Sigma + \Psi + \delta^2 \cdot \beta^2 \cdot \sigma_i^2} \text{ and } PE\Big|_{\sigma_m^2=0} = \beta \cdot \frac{\Sigma + \Psi}{\sigma_\eta^2 + \gamma^2 \cdot \sigma_s^2}. \tag{28}$$

Value relevance and price efficiency do not depend on managerial biasing incentives λ_x anymore. Hence, comparative statics with respect to the success fee δ become well-defined as they only depend on the buyer's reaction coefficient β. The derivative of value relevance with respect to δ is solely driven by the success fee such that E_β is strictly negative. The derivative of price efficiency is solely driven by the impact of δ on value relevance because the positive effect E_λ on price efficiency falls away:

$$\frac{d\beta}{d\delta}\Big|_{\sigma_m^2=0} < 0 \text{ and } \frac{dPE}{d\delta}\Big|_{\sigma_m^2=0} < 0. \tag{29}$$

In the case of no uncertainty about the managerial bias, value relevance and price efficiency are decreasing in success fee. From the buyer's perspective, the higher the success fee, the more uncertainty in form of intermediary variance is added to the report. An increasing success fee leads to a shift away from the known managerial incentives to the unknown intermediary incentives, thereby increasing overall uncertainty which results in a lower value relevance and consequently in a lower price efficiency.

To study the equilibrium properties of the model when there is only uncertainty about the managerial incentives, I set the intermediary uncertainty to zero, i.e., $\sigma_i^2 = 0$ and obtain the following expressions for value relevance and price efficiency:

$$\beta\Big|_{\sigma_i^2=0} = 1 \text{ and } PE\Big|_{\sigma_i^2=0} = \frac{\dfrac{\Sigma^2}{\Sigma + \lambda_x^2 \cdot \sigma_m^2} + \Psi}{\sigma_\eta^2 + \gamma^2 \cdot \sigma_s^2}. \tag{30}$$

The case of no uncertainty about intermediary incentives is equivalent to the benchmark case of zero success fee. Because the buyer perfectly knows the intermediary incentives, i.e., he knows the realization x_i, he simply deducts the bias from the intermediary's report r_i reflected in a negative α in the buyer's pricing function. Hence, the buyer learns the best estimate of the firm value given the entire information set of the intermediary. Since value relevance is always at the maximum level of one for all $\delta \in [0, 1]$, price efficiency only depends on the managerial biasing incentive coefficient λ_x. Consequently, the derivative of price efficiency with respect to success fee is solely driven by the derivative of λ_x with respect to δ, i.e., the positive effect E_λ described in Corollary 8:

$$\left.\frac{dPE}{d\delta}\right|_{\sigma_i^2=0} > 0. \tag{31}$$

From the buyer's perspective, the entire uncertainty in the report stems from unknown managerial incentives. A higher success fee reduces this uncertainty because it reduces managerial biasing incentives and shifts a higher weight towards the intermediary whose incentives are known. Consequently, price efficiency is increasing in success fee when there is no uncertainty about intermediary incentives.

If there is uncertainty about the incentives of both players, the manager and the intermediary, i.e., if $\sigma_m^2, \sigma_i^2 > 0$, then price efficiency is either increasing or decreasing in success fee, depending on the parameter settings. Furthermore, price efficiency is maximized for an intermediate success fee $\delta^* \in (0, 1)$. From a price efficiency perspective, this means that it is never optimal to set a corner solution success fee $\delta = 0$ or $\delta = 1$ because there always exists a success fee other than a corner solution which leads to a higher price efficiency.

Proposition 3 summarizes the findings on the ambiguous relation between price efficiency and success fee.

Proposition 3 *The effect of success fee on price efficiency is a priori ambiguous and is determined by the level of reporting uncertainty of the manager and the intermediary, measured by the variance of biasing incentives σ_m^2 and σ_i^2, respectively:*

a) If there is no uncertainty about managerial incentives, i.e., $\sigma_m^2 = 0$, but the incentives of the intermediary are uncertain, price efficiency is maximized for the corner solution success fee $\delta^* = 0$ and is always decreasing in success fee.

b) In the case of known incentives of the intermediary, i.e., $\sigma_i^2 = 0$, but uncertain managerial incentives, price efficiency is strictly increasing in success fee and is maximized for the corner solution success fee $\delta^* = 1$.

c) If there is uncertainty about the incentives of both, the manager and the intermediary, the success fee that maximizes price efficiency is an interior solution, i.e., $\delta^* \in (0, 1)$.

Figure 5 illustrates the findings from Proposition 3 and provides a graphical intuition for each of the three cases.

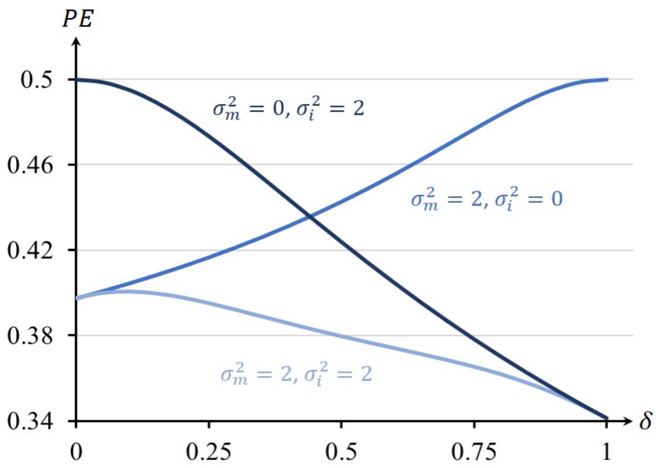

Figure 5 *The effect of success fee on price efficiency*
($\sigma_\eta^2 = \sigma_e^2 = \sigma_s^2 = \sigma_z^2 = 2$, $\gamma = 1$)

2.6 Conclusion

This study examines reporting bias in M&A transactions and its implications for value relevance and price efficiency. I find that especially the success fee rate plays an essential role by affecting misreporting incentives and therefore the information content in reported firm value.

The buyer's reaction coefficient to the intermediary report as a proxy for value relevance is always maximized in the case of zero success fee. Except for certain situations, value relevance is continuously decreasing in success fee so that the buyer relies less on the report for an increasing success fee when pricing the firm. With a success fee of zero, the intermediary has no incentive to bias and reports only his best estimate of firm value to the buyer. As a consequence, the buyer relies completely on the intermediary report when pricing the firm due to superior information of the intermediary.

Surprisingly, this does not need to be the case for the relation between price efficiency and success fee. The success fee influences biasing incentives of the manager and the intermediary which affects price efficiency via counteracting effects. Thereby, the success fee balances the two effects. I show that there always exists an interior solution for success fee that maximizes price efficiency if there is uncertainty about reporting incentives of both players, the manager and the intermediary. Compared to the case of zero success fee, price efficiency is always higher for a marginal positive success fee. At the other end, price efficiency is always higher for a success fee slightly below one compared to the case of a maximum success fee equal to one. From the buyer's perspective, a small but positive success fee or a success fee just below one is therefore always favorable compared to the corner solutions of a success fee equal to zero or equal to one.

As an additional result, the model shows that value relevance is always higher if the intermediary hired by the target is of high quality, i.e., his synergy signal variance is low.

Furthermore, I find that an increasing synergy relevance on the buyer's side always increases value relevance (and price efficiency). As an empirical implication, the model predicts that a buyer with a higher interest in synergy value places a higher weight on the intermediary's report when pricing the target firm compared to a buyer with lower synergy value interest. It is left for future empirical studies to test this hypothesis.

Appendix

Proof of Lemma 1

The linear equilibrium is derived by finding the best responses of each player given their conjectures of the others' strategies. In equilibrium, the conjectured coefficients are equal to the best response coefficients. Given the intermediary's conjectures of the manager's reporting function (see (7)) and the buyer's pricing function (see (9)), the intermediary's expected utility function becomes:

$$E[U_i] = x_i \cdot \delta \cdot (\alpha + \beta \cdot r_i) - \frac{1}{2} \cdot E[(\tilde{v} - r_i)^2 | r_m, z]. \tag{32}$$

By differentiating the utility function with respect to r_i, the best response of the intermediary given his information and conjectures results:

$$r_i = E[\tilde{v}|r_m, z] + x_i \cdot \delta \cdot \beta. \tag{33}$$

Matching coefficients yields:

$$\omega_0 = \omega_r = \omega_z = 0 \ \text{ and } \ \omega_x = \delta \cdot \beta. \tag{34}$$

Given the manager's conjectures of the intermediary's reporting function (see (8)) and the buyer's pricing function (see (9)), the manager's expected utility function takes the following form:

$$E[U_m] = x_m \cdot (1 - \delta) \cdot (\alpha + \beta \cdot (E\left[E_i[\tilde{v}|r_m, z]|r_m\right] + \omega_0 + \omega_r \cdot r_m + \omega_z \cdot z + \omega_x \cdot x_i)) - \frac{1}{2} \cdot E[(\tilde{v} - r_m)^2 | e]. \tag{35}$$

In the above expression, $E_i[.]$ denotes the expectation under the assumed intermediary conjecture of the manager's reporting function (see (7)) and thus represents a higher order belief of the manager. The manager can influence the conditional expectation by her report r_m. Therefore, the expression from the manager's view can be rewritten as conditional expectation on the manager's report r_m instead of her signal e. Further, the conditional expectation can be rewritten as:

$$E\left[E_i[\tilde{v}|r_m, z]|r_m\right] = \frac{Cov[\tilde{v}, \tilde{r}_m] \cdot Var\left[\tilde{z}\right] - Cov[\tilde{v}, \tilde{z}] \cdot Cov[\tilde{z}, \tilde{r}_m]}{Var\left[\tilde{z}\right] \cdot Var\left[\tilde{r}_m\right] - Cov[\tilde{z}, \tilde{r}_m]^2} \cdot \left(r_m - E\left[\tilde{r}_m\right]\right). \quad (36)$$

Since I assume that the two firm value components *asset value* $\tilde{\eta}$ and *synergy value* $\tilde{s}$ are uncorrelated, i.e., $Cov[\tilde{z}, \tilde{r}_m] = 0$, the term simplifies to:

$$E\left[E_i[\tilde{v}|r_m, z]|r_m\right] = \frac{Cov[\tilde{v}, \tilde{r}_m]}{Var\left[\tilde{r}_m\right]} \cdot \left(r_m - E\left[\tilde{r}_m\right]\right). \quad (37)$$

By plugging in the parameter values of the intermediary's reporting function from (34) and rewriting the expression $E[(\tilde{v} - r_m)^2|e]$, the manager's utility function can be written as:

$$E[U_m] = x_m \cdot (1-\delta) \cdot \left(\alpha + \beta \cdot \left(\frac{Cov[\tilde{v}, \tilde{r}_m]}{Var\left[\tilde{r}_m\right]} \cdot \left(r_m - E\left[\tilde{r}_m\right]\right) + \delta \cdot \beta \cdot \mu_i\right)\right) - \frac{1}{2} \cdot \left(Var\left[\tilde{v}|e\right] + \left(E\left[\tilde{v}|e\right] - r_m\right)^2\right). \quad (38)$$

Taking the derivative with respect to r_m yields the manager's best response:

$$r_m = E[\tilde{v}|e] + x_m \cdot \underbrace{(1-\delta) \cdot \beta \cdot \frac{\Sigma}{\Sigma + \lambda_x^2 \cdot \sigma_m^2}}_{\lambda_x}. \quad (39)$$

Note that the term $\Sigma = \frac{\sigma_\eta^4}{\sigma_\eta^2 + \sigma_e^2}$ corresponds to $Cov[\tilde{v}, \tilde{r}_m]$ and the term $\Sigma + \lambda_x^2 \cdot \sigma_m^2$ to $Var[\tilde{r}_m]$. Comparison with (7) and matching coefficients yields:

$$\lambda_0 = \lambda_e = 0 \text{ and } \lambda_x = (1-\delta) \cdot \beta \cdot \frac{Cov[\tilde{v}, \tilde{r}_m]}{Var[\tilde{r}_m]}. \quad (40)$$

Given the conjectures on the reporting strategies of the manager and the intermediary, the buyer observes the intermediary's report and tries to infer the total value of the firm. Thus, the buyer sets the price according to:

$$P(r_i) = E[\tilde{v}|r_i] = \underbrace{\frac{\dfrac{\Sigma^2}{\Sigma + \lambda_x^2 \cdot \sigma_m^2} + \Psi}{\dfrac{\Sigma^2}{\Sigma + \lambda_x^2 \cdot \sigma_m^2} + \Psi + \omega_x^2 \cdot \sigma_i^2}}_{\beta} \cdot (r_i - \omega_x \cdot \mu_i). \tag{41}$$

Note that the term $\Psi = \frac{\gamma^2 \cdot \sigma_s^4}{\sigma_s^2 + \sigma_z^2}$ corresponds to $\frac{Cov[\tilde{v},\tilde{z}]}{Var[\tilde{z}]}$. The term $\frac{\Sigma^2}{\Sigma + \lambda_x^2 \cdot \sigma_m^2} + \Psi$ is equal to $Cov\,[\tilde{v}, \tilde{r}_i]$ and $Var\,[E[\tilde{v}|r_m, z]]$.

Thus, matching coefficients with the conjectured pricing function (see (9)) yields:

$$\alpha = -\beta^2 \cdot \delta \cdot \mu_i \;\text{ and }\; \beta = \frac{Var\,[E[\tilde{v}|r_m, z]]}{Var\,[E[\tilde{v}|r_m, z]] + \omega_x^2 \cdot \sigma_i^2}. \tag{42}$$

$\square$

Proof of Corollary 1

According to Lemma 1, the three reaction coefficients λ_x, ω_x and β are implicitly defined in equilibrium:

$$\lambda_x = (1 - \delta) \cdot \beta \cdot \left(\frac{\Sigma}{\Sigma + \lambda_x^2 \cdot \sigma_m^2} \right), \tag{43}$$

$$\omega_x = \delta \cdot \beta = \delta \cdot \frac{\dfrac{\Sigma^2}{\Sigma + \lambda_x^2 \cdot \sigma_m^2} + \Psi}{\dfrac{\Sigma^2}{\Sigma + \lambda_x^2 \cdot \sigma_m^2} + \Psi + \omega_x^2 \cdot \sigma_i^2}, \tag{44}$$

$$\beta = \frac{\dfrac{\Sigma^2}{\Sigma + \lambda_x^2 \cdot \sigma_m^2} + \Psi}{\dfrac{\Sigma^2}{\Sigma + \lambda_x^2 \cdot \sigma_m^2} + \Psi + \delta^2 \cdot \beta^2 \cdot \sigma_i^2}. \tag{45}$$

The equilibrium conditions for λ_x and β can be rearranged as follows:

$$\underbrace{\lambda_x^3 + \frac{\Sigma}{\sigma_m^2} \cdot (\lambda_x - (1-\delta) \cdot \beta)}_{LHS_\lambda} = 0, \tag{46}$$

$$\underbrace{\beta^3 \cdot \delta^2 \cdot \sigma_i^2 + (\beta - 1) \cdot \left(\frac{\Sigma^2}{\Sigma + \lambda_x^2 \cdot \sigma_m^2} + \Psi \right)}_{LHS_\beta} = 0. \tag{47}$$

The following argumentation only holds for non-benchmark situations, i.e., when the success fee rate δ is non-zero and positive and therefore β is strictly lower than 1. First, consider the implicit function of λ_x (46). Suppose that $\lambda_x = 0$. The left hand side of (46), LHS_λ, becomes strictly negative which is a contradiction. The same argumentation holds for the implicit function of β. When $\beta = 0$, the left hand side of equation (47), LHS_β, becomes strictly negative which again is a contradiction. Thus, λ_x and β both have lower bounds of zero. The reaction coefficients have upper bounds, too. Suppose that $\lambda_x = (1-\delta) \cdot \beta$. Then again the equation (46) contradicts since LHS_λ is strictly positive. Similarly, suppose that $\beta = 1$. It follows that the LHS_β of (47) becomes strictly positive which is a contradiction. Hence, λ_x and β are bounded from above by $(1-\delta) \cdot \beta$ and 1, respectively. However, there exists a unique equilibrium for each reaction coefficient which lies in between their lower and upper bounds. This follows directly from the strictly positive slopes of LHS_λ in λ_x for a given β and LHS_β in β for a given λ_x:

$$\frac{\partial LHS_\lambda}{\partial \lambda_x} = 3 \cdot \lambda_x^2 + \frac{\Sigma}{\sigma_m^2} > 0, \tag{48}$$

$$\frac{\partial LHS_\beta}{\partial \beta} = 3 \cdot \beta^2 \cdot \delta^2 \cdot \sigma_i^2 + \frac{\Sigma^2}{\Sigma + \lambda_x^2 \cdot \sigma_m^2} + \Psi > 0. \tag{49}$$

Having shown that LHS_λ is strictly increasing in λ_x, LHS_β is strictly increasing in β and both reaction coefficients are bounded, the equilibrium coefficients λ_x and β_x must lie between their lower and upper bounds:

$$\lambda_x \in (0, (1-\delta) \cdot \beta) \quad \text{and} \quad \beta \in (0, 1). \tag{50}$$

It is easy to see that ω_x is bounded as follows:

$$\omega_x \in (0, \delta \cdot \beta)\,. \tag{51}$$

$\square$

Proof of Corollary 2

Plugging in $\delta = 0$ into Lemma 1 yields the coefficients shown in Corollary 2. $\square$

Proof of Corollary 3

According to Corollary 3, the manager's biasing coefficient λ_x is maximized in the benchmark case of a zero success fee. To show that λ_x reaches the maximum for δ equal to zero, it is sufficient to show that λ_x for $\delta = 0$ is strictly higher than λ_x for $\delta = 1$ and that λ_x is strictly decreasing in δ:

$$\lambda_x\Big|_{\delta=0} = \frac{Cov[\tilde{v}, \tilde{r}_m]}{Var[\tilde{r}_m]} > 0 = \lambda_x\big|_{\delta=1}. \tag{52}$$

The sign of $\partial\lambda_x/\partial\delta$ is negative and follows directly from the proof of Corollary 6. $\square$

Proof of Corollary 4

Analogously to the proof of Corollary 2, plugging in $\delta = 1$ into the coefficients of Lemma 1 yields the results of Corollary 4. $\square$

Proof of Corollary 5

Corollary 5 follows directly from a comparison of Corollary 2 and Corollary 4 and using Corollary 6 to see that the sign of $\partial\omega_x/\partial\delta$ is positive. $\square$

Proof of Corollary 6

To show comparative statics, I use the implicit function theorem. Define for the parameter $a \in \left\{\delta, \gamma, \sigma_m^2, \sigma_i^2, \sigma_\eta^2, \sigma_s^2, \sigma_z^2, \sigma_e^2\right\}$:

$$F(a,\beta,\lambda_x) = \begin{pmatrix} F_1 \\ F_2 \end{pmatrix} = \begin{pmatrix} \beta^3 \cdot \delta^2 \cdot \sigma_i^2 + (\beta - 1) \cdot (\Omega + \Psi) \\ \lambda_x^3 + \dfrac{\Sigma}{\sigma_m^2} \cdot (\lambda_x - (1-\delta) \cdot \beta) \end{pmatrix}. \tag{53}$$

with $\Sigma = \frac{\sigma_\eta^4}{\sigma_\eta^2 + \sigma_e^2}$, $\Omega = \frac{\Sigma^2}{\Sigma + \lambda_x^2 \cdot \sigma_m^2}$ and $\Psi = \frac{\gamma^2 \cdot \sigma_s^4}{\sigma_s^2 + \sigma_z^2}$. A comparison with (46) and (47) shows that the equilibrium coefficients β and λ_x are implicitly given by the condition $F(a,\beta,\lambda_x) = 0$. According to the implicit function theorem, β and λ_x can be stated as a function of a and the respective derivative is given by:

$$\begin{pmatrix} \dfrac{\partial\beta}{\partial a} \\ \dfrac{\partial\lambda_x}{\partial a} \end{pmatrix} = - \begin{pmatrix} \dfrac{\partial F_1}{\partial\beta}(a,\beta,\lambda_x) & \dfrac{\partial F_1}{\partial\lambda}(a,\beta,\delta) \\ \dfrac{\partial F_2}{\partial\beta}(a,\beta,\lambda_x) & \dfrac{\partial F_2}{\partial\lambda}(a,\beta,\lambda_x) \end{pmatrix}^{-1} \cdot \begin{pmatrix} \dfrac{\partial F_1}{\partial a}(a,\beta,\lambda_x) \\ \dfrac{\partial F_2}{\partial a}(a,\beta,\lambda_x) \end{pmatrix}. \tag{54}$$

Simple matrix algebra and substituting $3 \cdot \lambda_x^2 + \frac{\Sigma}{\sigma_m^2}$ with Δ yields:

$$- \begin{pmatrix} \dfrac{\partial F_1}{\partial\beta}(a,\beta,\lambda_x) & \dfrac{\partial F_1}{\partial\lambda}(a,\beta,\delta) \\ \dfrac{\partial F_2}{\partial\beta}(a,\beta,\lambda_x) & \dfrac{\partial F_2}{\partial\lambda}(a,\beta,\lambda_x) \end{pmatrix}^{-1} =$$

$$- \frac{1}{\underbrace{\left(3 \cdot \beta^2 \cdot \delta^2 \cdot \sigma_i^2 + \Omega + \Psi\right) \cdot \Delta + (1-\beta) \cdot \dfrac{2 \cdot (1-\delta) \cdot \lambda_x \cdot \Sigma \cdot \Omega}{\Sigma + \lambda_x^2 \cdot \sigma_m^2}}_{\Phi}} \cdot$$

$$\begin{pmatrix} \Delta & (\beta - 1) \cdot \dfrac{2 \cdot \lambda_x \cdot \sigma_m^2 \cdot \Omega}{\Sigma + \lambda_x^2 \cdot \sigma_m^2} \\ \dfrac{(1-\delta) \cdot \Sigma}{\sigma_m^2} & 3 \cdot \beta^2 \cdot \delta^2 \cdot \sigma_i^2 + \Omega + \Psi \end{pmatrix}. \tag{55}$$

It is easy to see that the denominator in Φ is positive. Evaluating (55) for $a \in \{\delta, \gamma\}$ yields:

$$\begin{pmatrix} \frac{\partial \beta}{\partial \delta} \\ \frac{\partial \lambda_x}{\partial \delta} \end{pmatrix} = -\Phi \cdot \begin{pmatrix} 2 \cdot \beta \cdot \left(\beta^2 \cdot \delta \cdot \sigma_i^2 \cdot \Delta - (1-\beta) \cdot \frac{\lambda_x \cdot \Sigma \cdot \Omega}{\Sigma + \lambda_x^2 \cdot \sigma_m^2}\right) \\ \beta \cdot \frac{\Sigma}{\sigma_m^2} \cdot \left(\beta^2 \cdot \delta \cdot \sigma_i^2 \cdot (2+\delta) + \Omega + \Psi\right) \end{pmatrix} \begin{matrix} \gtrless 0 \\ < 0 \end{matrix}, \tag{56}$$

$$\begin{pmatrix} \frac{\partial \beta}{\partial \gamma} \\ \frac{\partial \lambda_x}{\partial \gamma} \end{pmatrix} = \Phi \cdot \begin{pmatrix} (1-\beta) \cdot \frac{2 \cdot \gamma \cdot \sigma_s^4 \cdot \Delta}{\sigma_s^2 + \sigma_z^2} \\ (1-\beta) \cdot \frac{2 \cdot \gamma \cdot (1-\delta) \cdot \sigma_s^4 \cdot \Sigma}{\sigma_m^2 \cdot \left(\sigma_s^2 + \sigma_z^2\right)} \end{pmatrix} \begin{matrix} > 0 \\ > 0 \end{matrix}. \tag{57}$$

The given signs can easily be verified considering the restriction $0 < \beta < 1$.

The derivate of ω_x with respect to γ is solely determined by β and therefore positive, too. However, the derivate of ω_x with respect to δ requires further analysis due to two counteracting effects:

$$\frac{d\omega}{d\delta} = \underbrace{\frac{\partial \omega}{\partial \delta}}_{D_\omega > 0} + \underbrace{\underbrace{\frac{\partial \omega}{\partial \beta}}_{> 0} \cdot \underbrace{\frac{\partial \beta_x}{\partial \delta}}_{\gtrless 0}}_{I_\omega \gtrless 0}. \tag{58}$$

The direct effect D_ω is always positive while the sign of the indirect effect I_ω can be positive or negative. It is a priori not clear which effect dominates and what the resulting sign of the derivative is. However, plugging the derivatives into equation (58) and rearranging the expression by using simple algebra yields:

$$\frac{d\omega}{d\delta} = \frac{\beta \cdot (\Pi \cdot (\Xi + \Omega + \Psi) + 2 \cdot (1-\beta) \cdot \lambda \cdot \Sigma \cdot \Omega + \Sigma \cdot \Delta \cdot (\Xi + \Omega + \Psi))}{\Pi \cdot (3 \cdot \Xi + \Omega + \Psi) + 2 \cdot (1-\beta) \cdot (1-\delta) \cdot \lambda_x \cdot \Sigma \cdot \Omega + \Sigma \cdot \Delta \cdot (3 \cdot \Xi + \Omega + \Psi)}, \tag{59}$$

$$\text{where } \Xi = \beta^2 \cdot \delta^2 \cdot \sigma_i^2 \text{ and } \Pi = \lambda_x^2 \cdot \sigma_m^2 \cdot \Delta.$$

It is easy to see that the sign of equation (59) is strictly positive.

The derivatives of β with respect to the other parameters are presented below. The same substitutions for Σ, Ω, Ψ and Δ are used:

$$\frac{\partial \beta}{\partial \sigma_m^2} = -\Phi \cdot (1-\beta) \cdot \frac{\lambda_x^2 \cdot \Omega}{\Sigma + \lambda_x^2 \cdot \sigma_m^2} \cdot \left(\Delta + \frac{2 \cdot \Sigma}{\sigma_m^2} \right) < 0, \tag{60}$$

$$\frac{\partial \beta}{\partial \sigma_i^2} = -\Phi \cdot \beta^3 \cdot \delta^2 \cdot \Delta < 0, \tag{61}$$

$$\frac{\partial \beta}{\partial \sigma_\eta^2} = \Phi \cdot (1-\beta) \cdot \left(\Delta \cdot \Theta - \underbrace{(\lambda_x - (1-\delta) \cdot \beta)}_{<0 \text{ since } \lambda_x \in (0,\ (1-\delta)\cdot\beta)} \cdot \frac{\Omega^2 \cdot \Lambda}{\sigma_\eta^6} \right) > 0, \tag{62}$$

$$\frac{\partial \beta}{\partial \sigma_s^2} = \Phi \cdot (1-\beta) \cdot \frac{\gamma^2 \cdot \sigma_s^2 \cdot \left(2 \cdot \sigma_z^2 + \sigma_s^2\right) \cdot \Delta}{\left(\sigma_s^2 + \sigma_z^2\right)^2} > 0, \tag{63}$$

$$\frac{\partial \beta}{\partial \sigma_e^2} = -\Phi \cdot (1-\beta) \cdot \frac{\sigma_\eta^4 \cdot \Sigma \cdot \left(2 \cdot \lambda_x^2 \cdot \left(\Sigma + \sigma_m^2 \cdot \Delta\right) + \Sigma \cdot \Delta\right)}{\left(\sigma_\eta^2 + \sigma_e^2\right)^2 \cdot (\Sigma + \lambda_x^2 \cdot \sigma_m^2)^2} < 0, \tag{64}$$

$$\frac{\partial \beta}{\partial \sigma_z^2} = -\Phi \cdot (1-\beta) \cdot \frac{\Psi \cdot \Delta}{\sigma_s^2 + \sigma_z^2} < 0, \tag{65}$$

$$\text{where } \Theta = \frac{\sigma_\eta^6 \cdot \left(2 \cdot \sigma_e^2 + \sigma_\eta^2\right) \cdot \left(\sigma_\eta^2 + 2 \cdot \lambda_x^2 \cdot \sigma_m^2 \cdot \left(\sigma_\eta^2 + \sigma_e^2\right)\right)}{\left(\sigma_\eta^2 + \sigma_e^2\right)^2 \cdot \left(\sigma_\eta^2 + \lambda_x^2 \cdot \sigma_m^2 \cdot \left(\sigma_\eta^2 + \sigma_e^2\right)\right)^2} \text{ and}$$

$$\Lambda = 4 \cdot \lambda_x \cdot \sigma_e^2 + \sigma_\eta^2.$$

□

Proof of Corollary 7

The equilibrium coefficient β is defined in (41). Taking the derivative with respect to success fee δ and using Corollary 6 for the signs of the derivatives yields the results described in Corollary 7. Note that the same results are obtained if ω_x is not replaced with $\delta \cdot \beta$:

$$\frac{d\beta}{d\delta} = \underbrace{\underbrace{\frac{\partial\beta}{\partial\lambda_x}}_{<0} \cdot \underbrace{\frac{\partial\lambda_x}{\partial\delta}}_{<0}}_{I>0} + \underbrace{\underbrace{\frac{\partial\beta}{\partial\omega_x}}_{<0} \cdot \underbrace{\frac{\partial\omega_x}{\partial\delta}}_{>0}}_{I<0} . \tag{66}$$

□

Proof of Proposition 1

From Corollary 2 follows that the value relevance β reaches the maximum of one for a success fee of zero. Plugging these values into (56) yields $\partial\beta/\partial\delta\big|_{\delta=0} = 0$. To show that value relevance is always decreasing in success fee for small values of δ it is sufficient to show that the second derivate of β with respect to δ evaluated at $\delta = 0$ is negative. If $\delta = 0$ and $\beta = 1$ are plugged into the second derivative of β with respect to δ, the following negative expression is obtained:

$$\left.\frac{\partial^2\beta}{\partial\delta^2}\right|_{\delta=0} = -\Phi \cdot 2 \cdot \sigma_i^2 \cdot \Delta < 0, \quad \text{where } \left.\Phi\right|_{\delta=0} = \frac{1}{(\Omega + \Psi) \cdot \Delta}. \tag{67}$$

The condition for an increasing value relevance in success fee follows directly from Corollary 6. Setting $\partial\beta/\partial\delta > 0$ and using simple algebra yields the stated condition. □

Proof of Corollary 8

For the purpose of analyzing the interplay of price efficiency and success fee, we can rewrite the definition of price efficiency PE from equation (15) in equilibrium as follows:

$$PE = \beta \cdot \underbrace{\frac{Cov[\tilde{v}, \tilde{r}_i]}{Var[\tilde{v}]}}_{\Gamma}, \tag{68}$$

$$\text{where } Cov[\tilde{v}, \tilde{r}_i] = \frac{\Sigma^2}{\Sigma + \lambda_x^2 \cdot \sigma_m^2} + \Psi \text{ and } Var[\tilde{v}] = \sigma_\eta^2 + \gamma^2 \cdot \sigma_s^2.$$

From Corollary 6 follows directly the ambiguous derivative of β with respect to δ. Since Γ does not directly depend on the success fee δ, it is only indirectly affected via the impact of δ on the manager's biasing coefficient λ_x. It is easy to see that Γ is decreasing in λ_x, i.e., $\partial\Gamma/\partial\lambda_x < 0$. Knowing that λ_x is decreasing, it follows that the term Γ is increasing in δ. □

Proof of Proposition 3

To show that value relevance and price efficiency are decreasing in success fee for the case of known managerial incentives, I plug $\sigma_m^2 = 0$ into the definition of value relevance (45) and the expression of price efficiency (68), obtaining the following expressions:

$$\beta\Big|_{\sigma_m^2=0} = \frac{\Sigma + \Psi}{\Sigma + \Psi + \delta^2 \cdot \beta^2 \cdot \sigma_i^2} \text{ and } PE\Big|_{\sigma_m^2=0} = \beta \cdot \frac{\Sigma + \Psi}{\sigma_\eta^2 + \gamma^2 \cdot \sigma_s^2}. \tag{69}$$

It is easy to see that value relevance β is decreasing in success fee δ. Hence, it follows that price efficiency is also decreasing in success fee.

Similarly, plugging $\sigma_i^2 = 0$ into (45) and (68) to analyze value relevance and price efficiency for the case of known incentives of the intermediary, I obtain the following expressions:

$$\beta\Big|_{\sigma_i^2=0} = 1 \text{ and } PE\Big|_{\sigma_i^2=0} = \frac{\dfrac{\Sigma^2}{\Sigma + \lambda_x^2 \cdot \sigma_m^2} + \Psi}{\sigma_\eta^2 + \gamma^2 \cdot \sigma_s^2}. \tag{70}$$

Knowing that the sign of $\partial\lambda_x/\partial\delta$ is negative, it is easy to see that price efficiency is increasing in success fee δ.

To show that there is an interior solution for success fee where price efficiency is maximized, it is sufficient to prove existence. An interior solution δ^* exists if price efficiency is increasing at $\delta = 0$ and decreasing at $\delta = 1$, indicating that price efficiency is maximized for a success fee in between the corner points, i.e., that there exists a $\delta^* \in (0, 1)$.

Using the definition of $dPE/d\delta$ from Corollary 8 and plugging in the derivatives from

Corollary 6 yields:

$$\frac{dPE}{d\delta} = \frac{\partial\beta}{\partial\delta} \cdot \Gamma + \beta \cdot \frac{\partial\Gamma}{\partial\lambda_x} \cdot \frac{\partial\lambda_x}{\partial\delta} =$$

$$\underbrace{-\Phi \cdot 2 \cdot \beta \cdot \left(\beta^2 \cdot \delta \cdot \sigma_i^2 \cdot \Delta - (1-\beta) \cdot \frac{\lambda_x \cdot \Sigma \cdot \Omega}{\Sigma + \lambda_x^2 \cdot \sigma_m^2}\right)}_{\partial\beta/\partial\delta} \cdot \Gamma +$$

$$\beta \cdot \frac{\partial\Gamma}{\partial\lambda_x} \cdot \underbrace{\left(-\Phi \cdot \beta \cdot \frac{\Sigma}{\sigma_m^2} \cdot \left(\beta^2 \cdot \delta \cdot \sigma_i^2 \cdot (2+\delta) + \Omega + \Psi\right)\right)}_{\partial\lambda_x/\partial\delta}. \tag{71}$$

According to Corollary 2, the buyer's reaction coefficient β is equal to one in the corner point of zero success fee. Plugging $\delta = 0$ and $\beta = 1$ into (71) and knowing that $\partial\Gamma/\partial\lambda_x$ is negative, the derivative of price efficiency PE with respect to success fee evaluated at $\delta = 0$ becomes:

$$\left.\frac{dPE}{d\delta}\right|_{\delta=0} = -\Phi \cdot \underbrace{\frac{\partial\Gamma}{\partial\lambda_x}}_{<0} \cdot \frac{\Sigma}{\sigma_m^2} \cdot (\Omega + \Psi) > 0. \tag{72}$$

For the other corner point of a success fee equal to one, the manager has no incentive to bias and therefore λ_x is equal to zero. This follows directly from Lemma 1. Hence, the second term in (71) drops out and the expression becomes:[15]

$$\left.\frac{dPE}{d\delta}\right|_{\delta=1} = -\Phi \cdot 2 \cdot \beta^3 \cdot \frac{\sigma_i^2 \cdot \Sigma}{\sigma_m^2} \cdot \Gamma < 0. \tag{73}$$

□

[15] Note that $\Delta = 3 \cdot \lambda_x^2 + \frac{\Sigma}{\sigma_m^2}$.

Chapter 3

Investor Sophistication, Earnings Management and Market Efficiency*

Abstract

We study how the degree of investor sophistication affects firms' incentives for earnings management and market efficiency. In our model, a higher fraction of informed traders always reduces manipulation incentives and makes prices better indicators of firm value. However, we find ambiguous effects for markets where either a higher fraction of investors reacts only to a subset of the available information or where more investors trade for liquidity reasons. Specifically, we find that a higher fraction of liquidity traders can actually mitigate accounting manipulation and a higher fraction of limited attention traders almost always increases market efficiency. Our results suggest that carefully chosen measures of investor sophistication are an important prerequisite for empirical research on the association between investor sophistication and market outcomes.

Keywords: earnings management, limited attention, capital market, price efficiency

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3.1 Introduction

A rich body of theoretical and empirical accounting literature suggests that firms manipulate accounting reports to boost their stock market valuation. In this paper, we study how the degree of investor sophistication in the stock market affects the subtle interplay between the market response to potentially biased accounting reports and firms' incentives for earnings management and, more fundamentally, how the degree of investor sophistication affects the efficiency of the capital market.

Contrary to conventional wisdom and empirical evidence (Jiambalvo, Rajgopal, and Venkatachalam, 2002; Balsam, Bartov, and Marquardt, 2002) we find that a lower degree of investor sophistication can induce a weaker market response to manipulated accounting reports and reduce firms' incentives for accounting manipulation. More generally, we also identify conditions under which a lower degree of investor sophistication can increase the price efficiency of the stock market. Our study also suggests that carefully chosen measures of investor sophistication are a critical factor for the evaluation and empirical measurement of the relation between investor sophistication and capital market outcomes.

To address our research question, we introduce earnings management and varying degrees of investor sophistication into in a standard competitive linear rational expectations model (Vives, 2008; Goldstein and Yang, 2017). In the model, a manager with unknown reporting objectives as in Fischer and Verrecchia (2000) and Dye and Sridhar (2004) observes an unbiased signal about firm value and issues a biased accounting report to the capital market. Unlike prior signal jamming models of earnings management, we do not consider a representative risk-neutral investor but a capital market with a unit mass of heterogeneous investors that differ in their information processing capacities, information endowments and trading motives.

Our model features four trader types. As in the standard linear rational expectations model, there are informed investors, uninformed investors and liquidity traders where the latter place orders for the firm's shares based on exogenous liquidity reasons. All other traders are risk-averse portfolio investors considering the information about firm value in their investment decisions. While all traders observe the firm's accounting report, informed traders also observe a private signal of the firm's asset value. Because the informed traders' private information is reflected in their investment decisions, the share price is informative about firm value and allows investors to condition their orders on the private information contained in the share price.

As in Hirshleifer and Teoh (2003) and Hirshleifer, Lim, and Teoh (2011), we assume that a part of the uninformed investors exhibits limited information processing capacity preventing them from incorporating all available public information into their trading decisions. Specifically, we assume that limited attention traders base their investment decisions on the accounting report but do not consider the share price as an additional value signal in their investment decisions. Using this framework, we rank the four investor types in our model according to their degree of sophistication beginning with the most sophisticated informed investors, followed by the uninformed traders, the limited attention traders and the liquidity traders as the least sophisticated trader category.

The equilibrium stock price in our model is found by equating the demand of all four trader types with an exogenously given supply. The key variable in our model is the market response to the firm's earnings report because it not only determines the importance of the firms' accounting report for firm valuation but also the expected level of earnings management. We first show that an increased fraction of informed investors decreases the price response to the firm's accounting report and the equilibrium level of earnings management. The opposite effect holds true if the fraction of limited attention traders increases. In both cases, we consider changes within the group of risk-averse traders taking the uninformed investors as the numeraire. Consistent with conventional wisdom and empirical evidence (Jiambalvo, Rajgopal, and Venkatachalam, 2002; Balsam, Bartov, and Marquardt, 2002), these results suggest that an increasing degree of investor sophistication reduces the price response to biased accounting reports and thereby mitigates the firm's incentives for earnings management.

However, this intuition no longer holds if we consider a further decline in the aggregate sophistication level due to an increasing fraction of liquidity traders. Particularly, we find that a larger proportion of liquidity traders in the market can actually cause a lower price response to the firms accounting report and thereby reduce the firm's manipulation incentives. The reason for this result stems from two countervailing forces of liquidity trader demand on the earnings response coefficient. On one hand, an increasing share of liquidity traders implies a lower sensitivity of the aggregate demand for shares to the accounting report because a lower share of total trade is based on the firm's accounting report. On the other hand, a higher fraction of liquidity traders increases the aggregate valuation risk in the market which reduces the sensitivity of demand to changes of the share price. Because the price reaction to the firm's accounting report is determined by the ratio of both effects, a larger share of liquidity traders reduces the price response coefficient whenever the relative magnitude of the demand effect is larger than the relative decline of the price sensitivity.

We also study how the degree of investor sophistication affects the price efficiency of the stock market. We first show that an increasing fraction of informed investors increases the efficiency of the stock market in the sense that price becomes a more precise measure of value. In line with the findings of De Long et al. (1987), the opposite effect occurs if the fraction of liquidity traders increases. In both cases, this observation is consistent with the intuitively appealing notion that a higher degree of investor sophistication increases market efficiency because more informed trade makes prices better measures of value. However, our second main finding shows that this conclusion does not hold for all possible changes in the degree of sophistication. Specifically, we find that price efficiency can be increasing in the fraction of limited attention traders. The reason for this result is that the fraction of limited attention traders decreases both, the covariance between value and price and the variance of the price. Because price efficiency is negatively affected by a lower covariance but positively affected by a lower price volatility, more limited attention traders increase the price efficiency if the latter effect dominates the former.

Overall, the results of our study indicate that the effects of investor sophistication on the market response to biased accounting signals and the overall efficiency of capital markets are ambiguous and critically depend on the available measures of investor sophistication. While replacing uninformed traders with informed traders always affects outcomes as expected, an increasing share of investors who react only to a subset of the available information or who trade for exogenous reasons can actually have desirable consequences so that it mitigates accounting manipulation and increases market efficiency.

Our study contributes to the theoretical literature on earnings management in a capital market setting. In this literature, a manager issues a biased earnings report to increase the investors' perceptions of firm value. Early models such as Narayanan (1985) and Stein (1989) assume that market participants know all parameters of the manager's objective function and perfectly anticipate the bias in the earnings report. In such a setting the manager cannot affect the stock price but still bears the costs of manipulating the report. As shown by Fischer and Verrecchia (2000), this dilemma can partly be resolved if there is asymmetric information regarding the manager's reporting incentives. Specifically, they show that a higher uncertainty regarding the manager's interest in the stock price reduces the market reaction to the firm's earnings report and thereby mitigates the manager's reporting incentives. In a closely related paper, Dye and Sridhar (2004) study a setting where the market is uncertain about the manager's misreporting costs and derive similar results. While both approaches yield comparable insights about the relation between the market response to the firm's accounting report and the manager's manipulation incentives, we follow the latter approach to keep the comparative static analysis of our model tractable.

Several other papers extend the models of Fischer and Verrecchia (2000) and Dye and Sridhar (2004). Ewert and Wagenhofer (2005) introduce real earnings management and show that tighter accounting standards affect the manager's choice between real and accrual-based earnings management. Other studies considering uncertainty about managerial reporting objectives study the role of the audit committee for the manager's earnings management (Caskey, Nagar, and Petacchi, 2010), multiple firm disclosure (Heinle and Verrecchia, 2016), the role of endogenous compensation contracts (Goldman and Slezak, 2006) or the consequences of uncertainty about the manager's reputational concerns (Feller and Schäfer, 2019).

Unlike our paper, almost all signal jamming models of earnings management consider a capital market with a single representative risk-neutral investor. A notable exception is Fischer and Stocken (2004) who study earnings management in the context of a Kyle (1985) model. As in our paper, this model features a privately informed speculator and liquidity traders albeit all players are risk-neutral. Different from Kyle (1985), the speculator can be privately informed about the manager's reporting incentives in addition to his private value signal. Consistent with our findings, a speculator with more precise value information mitigates the manager's manipulation incentives. The opposite result holds if the speculator has better information about the manager's reporting incentives. Considering both effects, the presence of a privately informed speculator can have ambiguous effects on price efficiency.

To the best of our knowledge, our model is the first to study the role of different degrees of investor sophistication in the context of an earnings management model. Compared to Fischer and Stocken (2004), our model features risk-averse portfolio investors, that vary in their information endowment an information processing capacity. While models with multiple trader types (Vives, 2008; Goldstein and Yang, 2017) and limited attention traders (Hirshleifer and Teoh, 2003; Hirshleifer, Lim, and Teoh, 2011) are common in the finance literature, these models typically do not consider earnings management.[1] In addition, the population of liquidity traders is typically kept fixed in these models and not considered as a fraction of total mass of traders in the market. The results of our analysis suggest that these differences are important for a detailed understanding of the subtle relation between the degree of investor sophistication, earnings management incentives and the overall efficiency of capital markets.

Our model also contributes to the empirical literature on the role of investor sophistication in capital markets. For example, there is ample evidence of post-earnings announcement drift (see Ball and Brown, 1968; Bernard and Thomas, 1989) that causes stock prices to underreact to earnings surprises. Bartov, Radhakrishnan, and Krinsky (2000) find a negative association between post-earnings-announcement and investor sophistication where investor sophistication is measured by institutional ownership due to their superior information processing capacity. In related studies Della Vigna and Pollet (2009) and Hirshleifer, Lim, and Teoh (2009) present evidence for an empirical association between the presence of limited attention traders and post-earnings announcement drift. Finally, Jiambalvo, Rajgopal, and Venkatachalam (2002) and Balsam, Bartov, and Marquardt (2002) study the relation between investor sophistication and earnings management. They find that higher institutional ownership is negatively associated with discretionary accruals suggesting that the presence of sophisticated investors reduces earnings management.

The rest of the paper proceeds as follows. Section 3.2 outlines the model setup. Section 3.3 characterizes the equilibrium properties. Section 3.4 analyzes the relation between investor sophistication and earnings management. Section 3.5 studies the role of investor sophistication for price efficiency. Section 3.6 summarizes our findings and concludes.

[1] Hirshleifer and Teoh (2003) study a related problem where firms can strategically disclose pro forma earnings by deducting a given expense item from its GAAP earnings. Unlike our model, limited attention traders do not fully understand the firm's incentives for non-GAAP reporting and take the pro forma numbers at face value when valuing the firm.

3.2 Model setup

We consider a single period reporting game. At the beginning of the period (date $t = 1$), a firm with unknown net asset value $\tilde{v}$ is traded in a competitive capital market at an endogenous stock price p. At the end of the period (date $t = 2$), the firm's final asset value v is realized and consumed by investors. We assume that v is drawn from a normal distribution with mean zero and precision $1/\tau_v$ where $\tau_v = \sigma_v^{-2}$.

Prior to the market opening at date $t = 1$, the firm's manager privately observes a perfect signal of the firm's asset value and issues a potentially biased accounting report r to the market. Following prior literature (see Stein, 1989; Fischer and Verrecchia, 2000; Dye and Sridhar, 2004; Ewert and Wagenhofer, 2005), we assume that the manager maximizes the difference between the firm's stock price and the costs of misreporting. Accordingly, the manager's utility function takes the form:

$$U_M = p - \frac{1}{2} \cdot (r - v - \eta)^2. \tag{1}$$

To prevent that the market can perfectly back out the manager's reporting bias, we follow Dye and Sridhar (2004) in assuming that the manager's misreporting costs cannot be perfectly inferred by the market participants. Specifically, we let η be drawn form a normally distributed random variable $\tilde{\eta} \sim N\left(0, \frac{1}{\tau_\eta}\right)$ and assume that the manager privately observes its realization before issuing the report.

Unlike the prior earnings management literature, we assume that the firm is traded in a market with heterogeneous investors that differ regarding their information endowment, trading motives (Goldstein and Yang, 2017; Vives, 2008), and their information processing capacity (Hirshleifer and Teoh, 2003; Hirshleifer, Lim, and Teoh, 2011). Specifically, we assume that there is a unit mass of investors that can be of four different types. As in Goldstein and Yang (2017) and Vives (2008), there are *informed* investors, *uninformed* investors and *liquidity traders*. Informed and uninformed traders are risk-averse with CARA utility over final wealth W:

$$U_T = -\exp(-\gamma \cdot W). \tag{2}$$

The investors' coefficient of risk aversion is denoted by $\gamma > 0$. Investors can either buy q units of the firm's shares or invest funds into a riskless asset with zero return. With these assumptions an individual investor with initial wealth w_0 realizes a final wealth of $W = w_0 + q \cdot (v - p)$ at date 2. Because the initial endowment is immaterial for our results, we normalize it to zero in what follows.

Informed traders observe a private signal of the firm's asset value in addition to the accounting report. The signal is a noisy measure of v and takes the form:

$$\tilde{s}_i = \tilde{v} + \tilde{\varepsilon}_i, \tag{3}$$

where $\tilde{\varepsilon}_i \sim N\left(0, \frac{1}{\tau_\varepsilon}\right)$ is a normally distributed noise term determining the precision of the investor's private signal. The presence of privately informed investors implies that the price is informative about the firm's asset value. Accordingly, sophisticated investors can condition their demand for the risky asset on the value information contained in the stock price when placing their orders.

To study the consequences of varying degrees of investor sophistication, we assume that a part of the uninformed investors has limited information processing capacity. Therefore, these investors ignore the possibility of conditioning their asset demands on the value information contained in the asset price and consider only the public accounting report in valuing the firm. Following Hirshleifer and Teoh (2003) and Hirshleifer, Lim, and Teoh (2011), we label this fourth group of investors as *limited attention* traders because they only pay attention to the accounting report. With the total mass of investors normalized to one we let μ_I denote the fraction of informed traders and μ_U the fraction of uninformed traders that learn from prices, μ_L the share of limited attention traders and μ_X the fraction of liquidity traders. We assume that there are no other traders in the market and each fraction of traders is represented with a non-negative share so that $\sum \mu_n = 1$ for $\mu_n \in (0, 1)$ and $n \in \{I, U, L, X\}$.

While sophisticated investors and limited attention traders determine their demands for the firm's shares by maximizing their expected utility at date 1, liquidity traders place random orders for exogenous liquidity reasons. In this sense, liquidity traders are the least sophisticated investor category because their trading decision is completely random and independent of the public information available to the capital market. Specifically, we assume that the liquidity traders' demand for the firm's shares is randomly drawn from a normally distributed random variable $\tilde{x} \sim N\left(0, \frac{1}{\tau_x}\right)$. Finally, in order to determine the individual investors' demands and the market clearing stock price, we assume that there is unlimited supply of the riskless asset and an exogenously given supply quantity Q of the firm's shares where $Q \geq 0$.

3.3 Equilibrium

A rational expectations equilibrium of the reporting game requires the manager to choose a utility maximizing reporting strategy r for a given conjecture about the stock price p. Individual investors choose their demand for both assets so that their investment decisions maximize their expected utility conditional on their information endowment and the stock price p. The stock price is determined such that the market clears. That is, in equilibrium demand must equal supply.

We restrict our analysis to linear strategies considering the case where the manager's reporting strategy and the market pricing function are linear in the information available to the players when taking their decisions. In equilibrium, all conjectures about the players' strategies must be met. Specifically, we conjecture that the manager's reporting strategy is an affine function of her private value signal v and biasing costs η such that:

$$r = r_0 + r_v \cdot v + r_\eta \cdot \eta. \tag{4}$$

In a similar vein, the stock price is determined by the market clearing condition. This condition requires that the total demand for the firm's shares including the demand of liquidity traders equals its total supply Q. Because the demand is a function of the public and private information available to investors and the noise in the informed investors' private signals washes out by the law of large numbers, we conjecture that the equilibrium price is an affine function of the report r, the firm value v and the liquidity traders' demand x such that:

$$p = p_0 + p_r \cdot r + p_v \cdot v + p_x \cdot x. \tag{5}$$

The CARA-normal framework implies that sophisticated investors and limited attention traders maximize their expected utility and place asset demands as follows:

$$D_n = \frac{E\left[\tilde{v}|\Omega_n\right] - p}{\gamma \cdot Var\left[\tilde{v}|\Omega_n\right]}, \tag{6}$$

where $E\left[\tilde{v}|\Omega\right]$ and $Var\left[\tilde{v}|\Omega\right]$ are the first and second conditional moment of the firm's asset value given the information set Ω_n of investor type $n \in \{i, U, L\}$ and p is a given asset price. Because limited attention traders only consider the manager's report, their information set is $\Omega_L = \{r\}$ and the demand of a representative limited attention trader takes the form:

$$D_L = \frac{\tau_\eta \cdot (r - r_0) - (\tau_v + \tau_\eta) \cdot p}{\gamma}, \tag{7}$$

where we use the fact that the manager's report is a random variable from the investor's perspective and it holds that $E[\tilde{r}] = r_0$. The demand of a limited attention investor is increasing in the magnitude of the manager's accounting report and decreasing in the share price. Quite intuitively, the demand effect of the report is scaled by the precision of the reporting noise τ_η. This observation implies that a given accounting report has a higher impact on the demand for the firm's shares if investors are better informed about the actual costs of earnings management. Similarly, the price effect is scaled by the reciprocal of the conditional variance, $Var\left[\tilde{v}|\Omega_n\right]^{-1} = (\tau_\eta + \tau_v)$, which implies that a lower valuation risk increases the sensitivity of the demand for the firm's shares to changes in the stock price.

Unlike limited attention investors, sophisticated investors also consider the information contained in the stock price to learn about the firm's asset value. However, rather than considering the stock price as an additional signal in the investors' information set, it is sufficient to focus on an adjusted price signal s_p that carries only the incremental information content in addition to the public accounting report r. To this end, we define the incremental information contained in the stock price as a signal:

$$s_p = \frac{p - p_0 - p_r \cdot r}{p_v} = v + \frac{x}{\rho}, \quad \text{where } \rho = \frac{p_v}{p_x}. \tag{8}$$

Using this signal, the information set of informed trader i becomes $\Omega_i = \{r, s_i, s_p\}$ and the information set of a representative uninformed investor becomes $\Omega_U = \{r, s_p\}$. Accordingly, a representative uninformed investor demands

$$D_U = D_L + \frac{\rho^2 \cdot \tau_x}{\gamma} \cdot (s_p - p) \tag{9}$$

units of the firm's shares and a single informed investor demands

$$D_i = D_U + \frac{\tau_\varepsilon}{\gamma} \cdot (s_i - p) \tag{10}$$

units of the firm's shares. A closer expectation of the expressions in (9) and (10) shows that the additional information available to sophisticated investors triggers additional trade proportional to the precision of the additional signal whenever the asset price deviates from the signal values observed by the trader. Ordering the unit mass of traders in a decreasing order of information endowment and integrating over the mass of informed traders yields the aggregate demand of informed traders $D_I = \int_0^{\mu_I} D_i di$. Using this expression, the market clearing condition equates total asset demand and supply and reads as:

$$D_I + \mu_U \cdot D_U + \mu_L \cdot D_L + \mu_X \cdot x = Q. \tag{11}$$

Substituting the expressions for the demand of the different investor types in (7), (9) and (10), using the definition of s_p and the fact that s_i approaches v by the law of large numbers, we can solve the market clearing condition for p and determine the equilibrium of the reporting game as summarized in Proposition 1.

Proposition 1 *There exists a linear equilibrium of the reporting game where the manager's report takes the form as described in (4) and the coefficients of the reporting strategy are:*

$$r_0 = p_r \ \text{ and } \ r_v = r_\eta = 1. \tag{12}$$

The market price takes the form in (5) with the following equilibrium weights:

$$p_0 = -\frac{(1-\mu_X)\cdot p_r\cdot\tau_\eta + Q\cdot\gamma}{(1-\mu_X)\cdot(\tau_\eta+\tau_v) + (1-\mu_L-\mu_X)\cdot\rho^2\cdot\tau_x + \mu_I\cdot\tau_\varepsilon}, \tag{13}$$

$$p_r = \frac{(1-\mu_X)\cdot\tau_\eta}{(1-\mu_X)\cdot(\tau_\eta+\tau_v) + (1-\mu_L-\mu_X)\cdot\rho^2\cdot\tau_x + \mu_I\cdot\tau_\varepsilon}, \tag{14}$$

$$p_v = \frac{(1-\mu_L-\mu_X)\cdot\rho^2\cdot\tau_x + \mu_I\cdot\tau_\varepsilon}{(1-\mu_X)\cdot(\tau_\eta+\tau_v) + (1-\mu_L-\mu_X)\cdot\rho^2\cdot\tau_x + \mu_I\cdot\tau_\varepsilon}, \tag{15}$$

$$p_x = \frac{(1-\mu_L-\mu_X)\cdot\rho\cdot\tau_x + \mu_X\cdot\gamma}{(1-\mu_X)\cdot(\tau_\eta+\tau_v) + (1-\mu_L-\mu_X)\cdot\rho^2\cdot\tau_x + \mu_I\cdot\tau_\varepsilon}, \tag{16}$$

$$\textit{where}\ \ \rho = \frac{\mu_I}{\mu_X}\cdot\frac{\tau_\varepsilon}{\gamma}. \tag{17}$$

The manager's reporting strategy in Proposition 1 takes the form familiar from earnings management models as in Dye and Sridhar (2004). In equilibrium, the manager's report equals:

$$r = p_r + v + \eta. \tag{18}$$

That is, the manager reports the sum of her private value signal, the misreporting costs and a bias that is proportional to the market reaction to her earnings report. The higher the market reaction to the earnings report, the higher the equilibrium reporting bias. From the market's perspective, the manager's report is a random variable with precision $\tau_v \cdot \frac{\tau_\eta}{\tau_\eta+\tau_v}$ which is lower than the precision of the manager's unbiased value signal and increasing in the precision of the reporting noise τ_η. Therefore, the market puts a higher weight on the manager's report if it becomes more precise, i.e., if τ_η is increasing. As a consequence, a more precise accounting report triggers more earnings management in expectation and vice versa if the report becomes more noisy. At the same time, the noisy misreporting costs prevents the market from perfectly backing out the bias from the manager's report.[2] The equilibrium market response to the firm's earnings report takes the form of the ratio of the marginal demand changes triggered by a marginal change of the earnings report

[2] It is easy to demonstrate that in the absence of misreporting noise, the market would perfectly back out the bias from the manager's report and price the firm at its true value. In particular, if $\sigma_\eta^2 = 0$, the coefficients of the market pricing function would take the form $p_r = -p_0 = 1$ and $p_x = p_v = 0$.

and the market price of the firm's shares, respectively. Specifically, we can rewrite the price response to the firm's earnings report as:

$$p_r = \frac{(1-\mu_x)\cdot\frac{\partial D_L}{\partial r}\cdot\gamma}{-\left(\mu_L\cdot\frac{\partial D_L}{\partial p}+\mu_U\cdot\frac{\partial D_U}{\partial p}+\mu_I\cdot\frac{\partial D_I}{\partial p}\right)\cdot\gamma} = \frac{(1-\mu_x)\cdot\tau_\eta}{T}. \tag{19}$$

Because $\frac{\partial D_L}{\partial r}\cdot\gamma = \tau_\eta$, the marginal demand effect in the denominator of p_r is increasing in the precision of the manager's earnings report. Quite intuitively, a more precise earnings report has a positive effect on the aggregate demand for the firm's shares and triggers a higher price reaction. A closer inspection of the expression in (6) shows that the term in the denominator of (19) can be rewritten as:

$$T = \frac{\mu_L}{Var\left[\tilde{v}|\Omega_L\right]} + \frac{\mu_U}{Var\left[\tilde{v}|\Omega_U\right]} + \frac{\mu_I}{Var\left[\tilde{v}|\Omega_i\right]}, \tag{20}$$

which is a weighted average of the reciprocal of variances of the firm's asset value calculated by the three investor types given their information endowments and the denominator of the pricing coefficients in Proposition 1.[3] Because T is inversely related to average risk in the population of traders, a higher valuation risk reduces the marginal effect of a price change on the investor's aggregate demand and thereby triggers a higher price reaction to the firm's earnings report for a given precision of the manager's earnings report. The structure of the other pricing coefficients in Proposition 1 is similar to the structure of p_r.

3.4 Price response to accounting report

In this section, we study how the composition of the trader population in the stock market affects the components of the equilibrium price. Since the focus of our paper is on the relation between the degree of investor sophistication and earnings management, the main part of the analysis centers on the price reaction to the firm's earnings report. As we know from Proposition 1 and equation (18), a higher price reaction to the report triggers a higher reporting bias on the part of the manager such that changes of the equilibrium reaction p_r also induce a higher level of earnings management. Moreover, because $E[\tilde{v}] = E[\tilde{\eta}] = 0$,

[3] Using the fact that $\frac{1}{Var[\tilde{v}|\Omega_L]} = (\tau_\eta + \tau_v)$, $\frac{1}{Var[\tilde{v}|\Omega_U]} - \frac{1}{Var[\tilde{v}|\Omega_L]} = \rho^2\cdot\tau_x$ and $\frac{1}{Var[\tilde{v}|\Omega_i]} - \frac{1}{Var[\tilde{v}|\Omega_U]} = \tau_\varepsilon$, it is straightforward to show that $T = (1-\mu_X)\cdot(\tau_\eta+\tau_v) + (1-\mu_L-\mu_X)\cdot\rho^2\cdot\tau_x + \mu_I\cdot\tau_\varepsilon$.

the equilibrium price response to the firm's accounting report also determines the expected level of earnings management from an ex ante perspective. More formally, it holds that $E[\tilde{r} - \tilde{v}] = p_r$.

Before studying the relation between the composition of the investor base and the price response to the firm's accounting report in more detail, we briefly discuss two special cases. These limit cases serve as benchmarks for the subsequent comparative static analysis and facilitate the interpretation of results.

Corollary 1 *Benchmark analysis:*

a) If there are no liquidity traders ($\mu_X = 0$), the market puts no weight on the firm's earnings report.

b) If there are no informed traders ($\mu_I = 0$), the weight on the earning's report equals $p_r = \frac{\tau_\eta}{\tau_\eta + \tau_v}$. This result is independent of the relative amounts of other trader types in the market.

The first benchmark considers a scenario where there are no liquidity traders. In such a market, the equilibrium price fully reveals the information of the informed traders' private value signal and because this signal is on average correct by the law of large numbers, it holds that $p_v = 1$. In this case, the market puts zero weight on the firm's accounting report because it contains no incremental value information to investors given that the price fully reflects firm value. Consequently, the manager has no incentives to manage earnings.

The second benchmark considers the opposite extreme. If there are no informed traders, the accounting report is the only source of value information available to investors because the price contains no additional information on the asset value beyond the accounting report. In this case, there is no learning from prices and all risk-averse investors value the firm based on the same information. Accordingly, the price response to the accounting report reflects its information content on a stand-alone basis and equals the slope coefficient of an univariate regression of v on r. Because the demand of liquidity traders only makes the price signal redundant but carries no information on firm value, the relative fraction of liquidity traders in the market is immaterial for the price reaction on the firm's accounting report.

We examine next how changes in the distribution of trader types affect the price response to the firm's accounting report. To this end, we calibrate the comparative static analysis of our model so that any increase in the relative fractions of informed, limited attention and liquidity traders reduces the amount of uninformed traders and vice versa. Taking the group of uninformed investors as the numeraire for changes in the investor population allows us to consider the consequences of structural changes within the group of risk-averse investors as well as changes between the group of risk-averse investors and the population of liquidity traders. This procedure is already reflected in the expressions for the equilibrium price coefficients in Proposition 1 where we have used the fact that $\mu_U = 1 - \mu_I - \mu_L - \mu_X$ to determine the expressions for the coefficients of the equilibrium price in (5).

Corollary 2 *A relative increase of the fractions of informed (limited attention) traders within a given population of risk-averse investors implies the following changes to the price reactions on the firm's accounting report:*

$$\frac{\partial p_r}{\partial \mu_I} < 0, \ \frac{\partial p_r}{\partial \mu_L} > 0. \tag{21}$$

A higher share of informed traders reduces the price reaction to the firm's accounting report and thereby also the expected level of earnings management. The reason for this result is quite intuitive. A higher fraction of informed investors reduces the average valuation risk in the population of investors so that the demand for the firm's shares becomes more sensitive to changes in the firm's asset price. This effect is equivalent to a higher value of the term T in equation (20) which is inversely related to the valuation risk in the population of investors. Because the total share of risk-averse investors remains constant at $1-\mu_X$ and all investors in this group consider the firm's accounting report in proportion to its precision in determining their demand for the firm's shares, a change of the composition within this group of investors has no impact on the demand effect of the firm's accounting report as measured by the denominator in equations (14) and (19). Thus, with a constant demand effect of the accounting report and a stronger reaction to changes of the asset price, the equilibrium weight on the firm's accounting report is decreasing in μ_I. This result also implies that a larger fraction of more sophisticated investors partly protects the firm against the manager's incentives to manage the firm's earnings.

The opposite effect occurs if the fraction of limited attention traders within the group of uninformed investors becomes larger. While the demand effect of the accounting report remains constant again, a higher value of μ_L implies that fewer investors use the information contained in the firm's stock price to value the firm. Therefore, this change in the composition of the investor base is equivalent to an increase in the average valuation risk in the market. Because the higher information risk reduces the aggregate demand effect of changes in the firm's asset price (lower T) for a given demand effect of the accounting report, a higher fraction of limited attention traders increases the market response to the firm's accounting report and thereby the managers' incentives to manage earnings.

Having established that a lower degree of investor sophistication within the group of risk-averse investors increases the expected level of earnings management in the capital market, we study how an increasing fraction of liquidity traders affects the market reaction to the firm's accounting report. Provided that such a change in the investor base implies that a higher fraction of traders in the market places random orders for the firm's shares independent of the available information about firm value, an increasing fraction of liquidity traders can be regarded as a further deterioration of investor sophistication in the stock market. Perhaps surprisingly, our next result shows that such a decrease of investor sophistication does not necessarily translate into a higher level of earnings management.

Proposition 2 *A higher fraction of liquidity traders in the market can increase or decrease the price response to the firm's accounting report. Let $\bar{\mu}_X = 1 - \mu_I - \mu_L$ denote the maximum fraction of liquidity traders for given values of other trader types in the market. There exists a unique threshold μ_X^* such that:*

a) If $\mu_X^* \in (0, \bar{\mu}_X)$, the equilibrium price response p_r is increasing in μ_X if $\mu_X \leq \mu_X^*$ and decreasing in μ_X if $\mu_X > \mu_X^*$.

b) If $\mu_X^* > \bar{\mu}_X$, the equilibrium price response p_r is increasing in μ_X for all values of μ_X.

An increasing fraction of liquidity traders has two effects on the market demand for the firm's shares. On one hand, it increases the aggregate valuation risk in the market which reduces the stock price sensitivity of market demand (lower T). This effect is the same as for an increasing fraction of limited attention traders albeit for different reasons. On the other hand, a higher fraction of liquidity traders implies that a lower number of investors learn from the firm's earnings report and the information contained in the stock price. Thus, a larger share of liquidity traders reduces the precision of the price signal (lower ρ) which reduces the investor's ability to learn from price. However, different from an increase of μ_L, an increase of μ_X also reduces the fraction of investors $(1-\mu_X)$ that consider the firm's accounting report in their demand for the firm's shares.

While a lower demand reaction on the firm's accounting report reduces the equilibrium price response to r, a lower price sensitivity increases the market response to the firm's accounting report. Put differently, an increasing number of liquidity traders in the market reduces the numerator and the denominator of the equilibrium response coefficient in equations (14) and (19) so that the overall effect of μ_X on p_r is ambiguous. Whenever the price sensitivity effect in the denominator is weaker than the impact of a lower price response to the accounting report in the numerator, a higher fraction of liquidity traders reduces the price response to the firm's accounting report and vice versa. More fundamentally, these results imply that a lower degree of investor sophistication in the stock market can reduce the manager's earnings management incentives rather than increasing them.

Our next result shows how changes in the composition of the investor base affect the relative importance of accounting information to investors.

Proposition 3 *Any change in the price response to the firm's accounting report caused by a change in the composition of the investor base has the opposite effect on the price response to the value signal contained in p. The effect is proportional to the information content of the firm's accounting report:*

$$\frac{\partial p_r}{\partial \mu_n} = -\frac{\tau_\eta}{\tau_\eta + \tau_v} \cdot \frac{\partial p_v}{\partial \mu_n} \quad \textit{for} \;\; n \in \{I, L, X\}. \tag{22}$$

According to Proposition 3, a higher price reaction to the firm's earnings report goes hand in hand with a lower price reaction to the value signal contained in the market price. The reason for this relation is that a change in the composition of the investor base changes the relative impact of the two value signals for the demand of shares. For example, an increasing fraction of limited attention investors does not affect the marginal demand change induced by the accounting report but it reduces the marginal demand induced by the value information contained in the share price because fewer investors consider this information in their investment decision. Because the price sensitivity of demand in the denominator of p_r and p_v goes down and the relative change of the demand effect is stronger than the change of the price sensitivity, p_r is increasing in μ_L whereas p_v is decreasing in μ_L. Moreover, since

$$\frac{\partial p_r}{\partial \mu_L} = \frac{(1-\mu_X)\cdot\tau_\eta\cdot\rho^2\cdot\tau_x}{T^2}, \tag{23}$$

$$\frac{\partial p_v}{\partial \mu_L} = -\frac{(1-\mu_X)\cdot(\tau_\eta+\tau_v)\cdot\rho^2\cdot\tau_x}{T^2}, \tag{24}$$

the ratio of marginal changes is a negative constant and proportional to the coefficient of an univariate regression of v on r. As we show in the proof of the proposition, the same relation holds for the changes in the fraction of other investor types.

Figures 1 and 2 illustrate the relation between the equilibrium price responses to r and v and a varying fraction of liquidity traders. Figure 1 illustrates case a) in Proposition 2. It can be seen that the p_r is increasing in μ_X up to the point where $\mu_X = \mu_X^*$ and decreasing beyond this point. The opposite effect holds for p_v which is decreasing in μ_X as long as $\mu_X \leq \mu_X^*$ and increasing beyond this point. Figure 2 illustrates case b) in Proposition 2. It can be seen that p_r is strictly increasing in μ_X whereas p_v is strictly decreasing in μ_X.

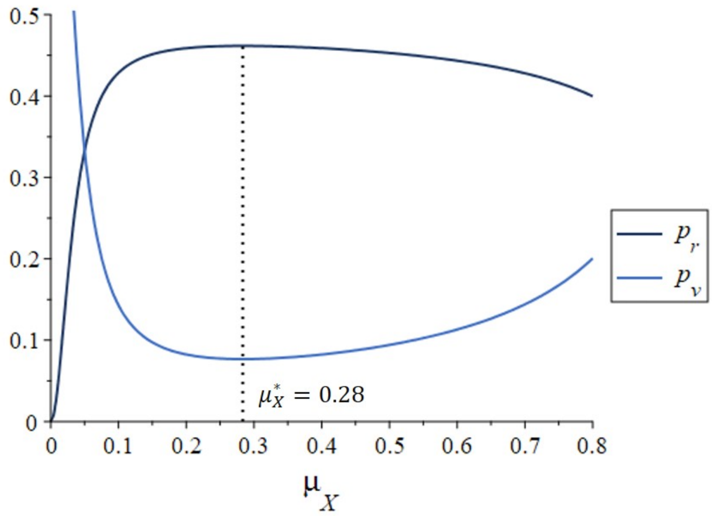

Figure 1 *Ambiguous effect of liquidity traders on earnings management*
($\mu_U = \mu_I = 0.1$, $\gamma = 1.0$, $\tau_\varepsilon = \tau_\eta = \tau_v = \tau_x = 0.5$)

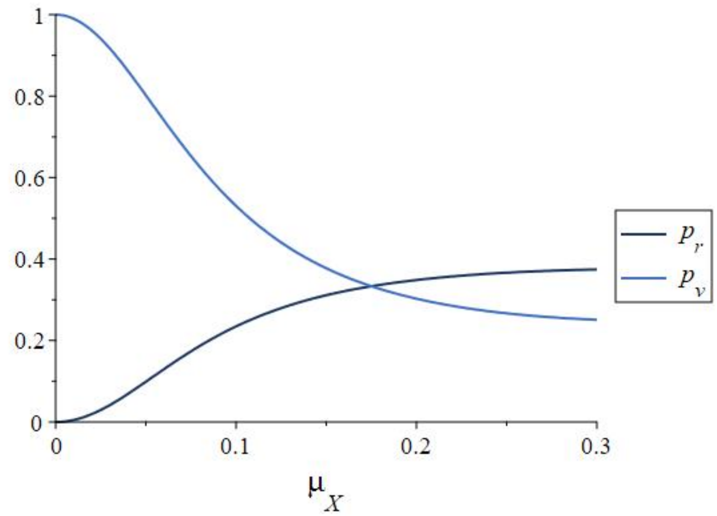

Figure 2 *Strictly increasing earnings management*
($\mu_U = \mu_I = 0.35$, $\gamma = 1.0$, $\tau_\varepsilon = \tau_\eta = \tau_v = \tau_x = 0.5$)

3.5 Price efficiency

This section studies how the composition of the investor base affects the informational efficiency of the capital market. Market or price efficiency refers to the question on how well the market price of a firm's stock represents its fundamental value (Goldstein and Yang, 2017). In this paper, we measure price efficiency as the relative difference between the variance of the fundamental value and the conditional value variance for a given stock price:

$$PE = \frac{Var\,[\tilde{v}] - Var\,[\tilde{v}|p]}{Var\,[\tilde{v}]}, \quad \text{where} \quad PE \in [0, 1]. \tag{25}$$

This measure is defined so that higher values indicate a more efficient capital market. That is, if the price is a perfect measure of firm value, it holds that $PE = 1$ and if the price contains no value-relevant information, this measure takes the value of zero.[4]

[4] There are several measures of price efficiency in the literature. For example, Goldstein and Yang (2017) define market efficiency as the reciprocal of the conditional variance $Var\,[\tilde{v}|p]$. Consistent with our measure in (25), a higher conditional variance indicates a less efficient market.

Corollary 3 *An increasing fraction of informed traders increases price efficiency. An increasing number of liquidity traders decreases price efficiency. That is, it holds that:*

$$\frac{\partial PE}{\partial \mu_I} > 0, \quad \frac{\partial PE}{\partial \mu_X} < 0. \tag{26}$$

Our results in Corollary 3 are quite intuitive. A higher fraction of informed traders increases the efficiency of the stock market, whereas a higher fraction of liquidity traders reduces price efficiency. The reason for the first result is that informed traders possess private information about firm value that is reflected in the market price through their demand for the firm's stock. A higher fraction of traders leads to more informed trade and makes the market price more informative about the fundamental value. On the other hand, a higher fraction of liquidity traders implies that a lower fraction of the total trading volume is based on information about the firm's fundamentals so that the price becomes a less precise measure of firm value.

Considering our measure of price efficiency in (25), these results can be formally explained by the effect of a changing trader population on the variance of the stock price $\tilde{p}$ and the covariance between $\tilde{p}$ and $\tilde{v}$. If we substitute for the conditional variance in the definition of PE, we can rewrite this expression as:

$$PE = \frac{\tau_v \cdot Cov(\tilde{v}, \tilde{p})^2}{Var(\tilde{p})}, \tag{27}$$

which indicates that a higher covariance between value and price increases the price efficiency and a higher variance of the stock price decrease price efficiency. Consistent with our results in Corollary 3, we find that a higher fraction of informed traders increases $Cov(\tilde{v}, \tilde{p})$ and a higher fraction of liquidity traders decreases $Cov(\tilde{v}, \tilde{p})$. However, we also find that the same effects hold for the variance of the price so that there are countervailing effects that reduce the price efficiency in the first case and increases it in the latter case. The presence of these effects is intuitive if we consider that:

$$Var(\tilde{p}) = \tau_v \cdot Cov(\tilde{v}, \tilde{p})^2 + \tau_\eta^{-1} \cdot p_r^2 + \tau_x^{-1} \cdot p_x^2, \tag{28}$$

which implies that a higher covariance increases price variance and vice versa for a lower covariance. However, because the price efficiency is measured as a ratio, the comparative static analysis must consider the relative changes of the terms in the numerator and the denominator to determine the sign of the overall effect. As we demonstrate in the appendix, for the share of informed traders the relative increase of the term in the numerator of equation (27) is higher than the relative increase of the price variance in the denominator. It follows that an increasing fraction of informed investors always increases the price efficiency. Likewise, the relative decrease of the covariance term in the numerator of (27) caused by an increasing fraction of liquidity traders is stronger than the decrease of the total price variance in the denominator.

More fundamentally, the results in Corollary 3 suggest that a lower degree of investor sophistication generally reduces price efficiency. Our next result shows that this conclusion is premature and does not always hold if we vary the degree of investor sophistication within the group of risk-averse traders.

Proposition 4 *A higher fraction of limited attention traders in the market can increase or decrease the price efficiency. Let $\bar{\mu}_L = 1 - \mu_I - \mu_X$ denote the maximum fraction of limited attention traders for given values of other trader types in the market. There is a unique threshold:*

$$\mu_L^* = \frac{\gamma \cdot \mu_X}{\rho \cdot \tau_x}, \tag{29}$$

such that:

a) If $\mu_X^* \in (0, \bar{\mu}_X)$, price efficiency is increasing in μ_L if $\mu_L \leq \mu_L^*$ and decreasing in μ_L if $\mu_L > \mu_L^*$.

b) If $\mu_L^* > \bar{\mu}_L$, price efficiency is strictly increasing in μ_L for all values of μ_L.

Perhaps most surprisingly, the results in Proposition 4 suggest that markets with a lower fraction of sophisticated investors can exhibit a higher price efficiency. The reason for this effect is twofold. As noted for the share of liquidity traders, a higher fraction of limited attention traders reduces the covariance between the stock price and firm value because a lower fraction of investors considers the value information contained in the stock price in its investment decisions. This effect also reduces the price variance which is decreasing in μ_L. However, because the demand of liquidity traders also determines the noise of the price signal s_p, less use of this signal by market participants reduces the weight of the price response to the demand of liquidity traders which further decreases the variance of the stock price. If this effect is sufficiently pronounced, the relative reduction of the price variance exceeds the relative reduction of the covariance term in (27) and (28) so that the price efficiency is increasing in μ_L. Considering this effect and the structure of the price variance in (28), it is intuitively clear why μ_L^* is increasing in the fraction of liquidity traders (μ_X) and decreasing in τ_x.

The two solutions described in Proposition 4 are illustrated in Figures 3 (case a)) and 4 (case b)). The first case in Figure 3 considers a scenario where the price efficiency is concave in μ_L, increasing up to the value of μ_L^* and decreasing beyond that point. It is only in the latter region that a lower investor sophistication reduces price efficiency. As illustrated in Figure 4, the price efficiency is generally increasing in μ_L if the reduction of the price reaction to the demand of liquidity traders has a sufficiently high impact on the price variance. In Figure 4, this impact is captured by a higher risk aversion which has an equivalent effect on price efficiency because it implies that investors generally put a higher weight on x which increases the magnitude of the additional variance reduction in the same way as a higher fraction of liquidity traders.

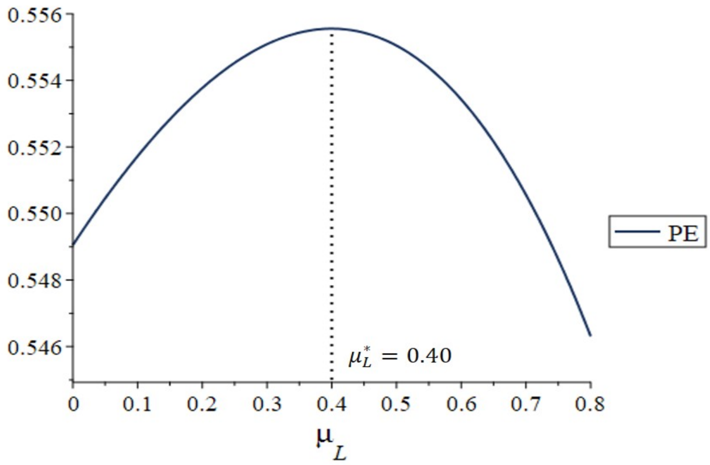

Figure 3 *Ambiguous effect of limited attention on price efficiency* ($\mu_I = \mu_X = 0.1$, $\gamma = 1.0$, $\tau_\varepsilon = \tau_\eta = \tau_v = \tau_x = 0.5$)

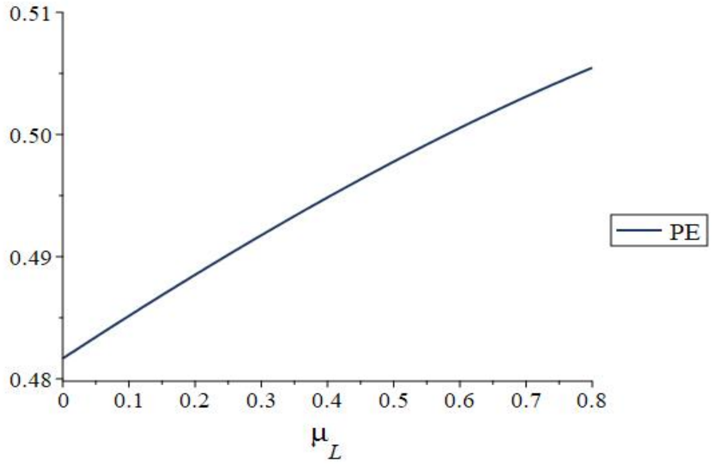

Figure 4 *Strictly increasing price efficiency in limited attention*
($\mu_I = \mu_X = 0.1$, $\gamma = 2.0$, $\tau_\varepsilon = \tau_\eta = \tau_v = \tau_x = 0.5$)

3.6 Conclusion

We study how the degree of investor sophistication affects firms' incentives for earnings management and market efficiency. Our analysis features a signal jamming model of earnings management in the context of a linear rational expectations model with heterogeneous investors. A manager with unknown reporting objectives observes an unbiased signal about firm value and issues a biased accounting report to the capital market. The market features four trader types: informed investors, uninformed investors, limited attention traders and liquidity traders. While all other traders are risk-averse portfolio investors considering different sources of information about firm value in their investment decisions, liquidity traders place orders for the firm's shares for exogenous reasons.

All traders observe the firm's accounting report but informed traders also observe a private signal of the firm's asset value. Because the informed traders' private information is reflected in their investment decisions, the share price is informative about firm value. In contrast to informed and uninformed investors that always use the stock price as an additional value signal, limited attention traders exhibit constrained information processing capacity that prevent them from extracting the value information from the market price and restrict them to value the firm based on the public accounting report. Using this framework allows us to rank the four investor types in our model according to their degree of sophistication beginning with informed investors, followed by the uninformed traders, limited attention traders and liquidity traders as the least sophisticated trader category.

We first show that an increased fraction of informed investors decreases the price response to the firm's accounting report and the equilibrium level of earnings management. Consistent with conventional wisdom, these results suggest that an increasing degree of investor sophistication reduces the price response to biased accounting reports and thereby mitigates the firm's incentives for earnings management. Perhaps surprisingly, this intuition no longer holds if we consider an increasing share of liquidity traders. Particularly, we find that a larger proportion of liquidity traders in the market can actually cause a lower price response to the firms accounting report, thereby reducing the manager's manipulation incentives.

We also study how the degree of investor sophistication affects the price efficiency of the stock market and find that an increasing fraction of informed investors increases the efficiency of the stock market in the sense that the price becomes a more precise measure of value. The opposite effect occurs if the fraction of liquidity traders increases. Most surprisingly we find that price efficiency is increasing in the fraction of limited attention traders whenever their presence has a stronger impact on the volatility of the stock price than on its covariance with the firm value.

The results of our study indicate that the degree of investor sophistication can have ambiguous effects on the market response to biased accounting signals and the overall efficiency of capital markets. Our findings also suggest that carefully chosen measures of investor sophistication are crucial for studying the empirical association between investor sophistication and market outcomes.

Appendix

Proof of Proposition rotect1

According to (1), the manager maximizes her utility for a given conjecture about the stock price p,

$$U_m = p_0 + p_r \cdot r + p_v \cdot v + p_x \cdot x - \frac{1}{2} \cdot (r - v - \eta)^2, \tag{30}$$

with respect to her report r. Given the realizations of her value signal v and reporting noise η, the manager's optimal report takes the form:

$$r = p_r + v + \eta. \tag{31}$$

Matching coefficient with the conjectured equilibrium strategy in equations (4) then yields:

$$r_0 = p_r \text{ and } r_v = r_\eta = 1. \tag{32}$$

For a given information endowment and conjecture about the manager's report, all risk-averse traders determine the conditional moments of firm value and their demand for the firm's shares as defined in (6). Matching supply and demand considering the expressions in (9) and (10) as well as the demand of liquidity traders, the market clearing condition in (11) reads as:

$$(1 - \mu_X) \cdot D_L + (\mu_I + \mu_U) \cdot \frac{\rho^2 \cdot \tau_x}{\gamma} \cdot (s_p - p) + \mu_I \cdot \int_0^{\mu_I} \frac{\tau_\varepsilon}{\gamma} \cdot (s_i - p)\, di + \mu_X \cdot x = Q. \tag{33}$$

Considering the expressions of D_L in (7), s_p in (8) as well as the facts that $\sum_n \mu_U = 1$ and $\int_0^{\mu_I} \varepsilon_i \cdot di = 0$ by the law of the large numbers, we can solve the market clearing condition for p. Rearranging terms and matching coefficients with the conjectured equilibrium price function in equation (5) yields the expressions in the proposition:

$$p_0 = -\frac{(1-\mu_X)\cdot p_r \cdot \tau_\eta + Q\cdot\gamma}{T}, \quad p_r = \frac{(1-\mu_X)\cdot\tau_\eta}{T}, \tag{34}$$

$$p_v = \frac{(1-\mu_L-\mu_X)\cdot\rho^2\cdot\tau_x + \mu_I\cdot\tau_\varepsilon}{T}, \quad p_x = \frac{(1-\mu_L-\mu_X)\cdot\rho\cdot\tau_x + \mu_X\cdot\gamma}{T}, \tag{35}$$

$$\text{where } T = (1-\mu_X)\cdot(\tau_\eta+\tau_v) + (1-\mu_L-\mu_X)\cdot\rho^2\cdot\tau_x + \mu_I\cdot\tau_\varepsilon \tag{36}$$

$$\text{and } \rho = \frac{p_v}{p_x} = \frac{\mu_I}{\mu_X}\cdot\frac{\tau_\varepsilon}{\gamma}. \tag{37}$$

□

Proof of Corollary 1

In the absence of liquidity traders ($\mu_X = 0$), the price coefficients in Proposition 1 take the values:

$$p_0 = p_r = p_x = 0, \quad p_v = 1. \tag{38}$$

If there are no informed traders ($\mu_I = 0$), the price coefficients in Proposition 1 take the values:

$$p_0 = -\frac{p_r\cdot(1-\mu_X)\cdot\tau_\eta + \gamma\cdot Q}{(1-\mu_X)\cdot(\tau_\eta+\tau_v)}, \quad p_r = \frac{\tau_\eta}{\tau_\eta+\tau_v}, \quad p_v = 0, \quad p_x = \frac{\gamma\cdot\mu_X}{(1-\mu_X)\cdot(\tau_\eta+\tau_v)}. \tag{39}$$

Evidently, p_r is independent of the distribution of traders in the market in this case. □

Proof of Corollary 2

Differentiating the equilibrium coefficient p_r in Proposition 1 with respect to the relative mass of trader types μ_I and μ_L yields:

$$\frac{\partial p_r}{\partial \mu_I} = -\frac{(1-\mu_X)\cdot\tau_\eta}{T^2}\cdot\frac{\partial T}{\partial \mu_I} < 0, \tag{40}$$

$$\frac{\partial p_r}{\partial \mu_L} = -\frac{(1-\mu_X)\cdot\tau_\eta}{T^2}\cdot\frac{\partial T}{\partial \mu_L} > 0, \tag{41}$$

$$\text{where } \frac{\partial T}{\partial \mu_I} = \tau_\varepsilon + 2\cdot\left(\frac{1-\mu_L-\mu_X}{\mu_I}\right)\cdot\rho^2\cdot\tau_x \text{ and } \frac{\partial T}{\partial \mu_L} = -\rho^2\cdot\tau_x.$$

□

Proof of Proposition 2

Differentiating the equilibrium coefficient p_r in Proposition 1 with respect to the fraction of liquidity traders yields:

$$\frac{\partial p_r}{\partial \mu_X} = -\frac{\tau_\eta}{T^2}\cdot\left(T + (1-\mu_X)\cdot\frac{\partial T}{\partial \mu_X}\right) = -\frac{\tau_\eta}{T^2}\cdot F(\mu_X), \tag{42}$$

$$\text{where } \frac{\partial T}{\partial \mu_X} = -(\tau_\eta+\tau_v) - \left(1 + 2\cdot\left(\frac{1-\mu_L-\mu_X}{\mu_X}\right)\right)\cdot\rho^2\cdot\tau_x < 0. \tag{43}$$

Because $T > 0$ and $\frac{\partial T}{\partial \mu_X} < 0$, the sign of the derivative in (42) is ambiguous and depends on the sign of the expression $F(\mu_X)$. Because it holds that:

$$\lim_{\mu_X \to 0} F(\mu_X) = -\infty, \tag{44}$$

it follows that $\frac{\partial p_r}{\partial \mu_X} > 0$ for small values of μ_X. However, because T is positive and decreasing concave in μ_X, it holds that:

$$\frac{\partial F(\mu_X)}{\partial \mu_X} = (1-\mu_X)\cdot\frac{\partial^2 T}{\partial \mu_I^2} > 0. \tag{45}$$

Considering the parameter range of $\mu_X \in (0, \bar{\mu}_X)$, where $\bar{\mu}_X = 1 - \mu_I - \mu_L$, there exists a critical value μ_X^* that solves the equation $F(\mu_X^*) = 0$ for μ_X whenever it holds that $F(\bar{\mu}_X) > 0$. Otherwise, if $F(\bar{\mu}_X) < 0$, p_r is increasing in μ_X for all $\mu_X \in (0, \bar{\mu}_X)$.

Using the expressions in (36) and (43), the critical value of μ_X^* can be found as the solution of the equation:

$$\mu_I \cdot \tau_\varepsilon - \left((1-\mu_X) + (2 - 3\cdot\mu_X)\cdot\left(\frac{1-\mu_L-\mu_X}{\mu_X}\right)\right)\cdot\rho^2\cdot\tau_x = 0. \tag{46}$$

□

Proof of Proposition 3

Differentiating the equilibrium coefficient p_v in Proposition 1 with respect to the trader fractions μ_I, μ_L and μ_X yields:

$$\frac{\partial p_v}{\partial \mu_n} = \frac{(1-\mu_X)\cdot(\tau_v+\tau_\eta)}{T^2}\cdot\frac{\partial T}{\partial \mu_n}, \quad n \in \{I, L\} \tag{47}$$

$$\text{and} \quad \frac{\partial p_v}{\partial \mu_X} = \frac{(\tau_v+\tau_\eta)}{T^2}\cdot\left(T + (1-\mu_X)\cdot\frac{\partial T}{\partial \mu_X}\right). \tag{48}$$

Comparing this expression to the expressions in (40), (41) and (42) shows that:

$$\frac{\partial p_r}{\partial \mu_n} = -\frac{\tau_\eta}{\tau_\eta+\tau_v}\cdot\frac{\partial p_v}{\partial \mu_n} \quad \text{for} \quad n \in \{I, L, X\}. \tag{49}$$

□

Proof of Corollary 3

Using the fact that:

$$Cov(\tilde{v}, \tilde{p}) = (p_r + p_v)\cdot\tau_v^{-1}, \tag{50}$$

we can write the price efficiency in (27) as follows:

$$PE = \frac{\tau_v^{-1} \cdot (p_r + p_v)^2}{\tau_v^{-1} \cdot (p_r + p_v)^2 + \tau_\eta^{-1} \cdot p_r^2 + \tau_x^{-1} \cdot p_x^2}. \tag{51}$$

Because all coefficients of the pricing equation in Proposition 1 have the same denominator, this expression can be simplified to the form:

$$PE = \frac{A(\mu_I, \mu_L, \mu_X)}{A(\mu_I, \mu_L, \mu_X) + B(\mu_L, \mu_X)}, \tag{52}$$

$$\text{where } A(\mu_I, \mu_L, \mu_X) = \tau_v^{-1} \cdot (\alpha_r + \alpha_p)^2, \;\; B(\mu_L, \mu_X) = \tau_\eta^{-1} \cdot \alpha_r^2 + \tau_x^{-1} \cdot \alpha_x^2$$

and α_r, α_p, and α_x are the numerators of the pricing coefficients in Proposition 1, that is:

$$\alpha_r = (1 - \mu_X) \cdot \tau_\eta,$$

$$\alpha_p = (1 - \mu_L - \mu_X) \cdot \rho^2 \cdot \tau_x + \mu_I \cdot \tau_\varepsilon,$$

$$\alpha_x = (1 - \mu_L - \mu_X) \cdot \rho \cdot \tau_x + \mu_X \cdot \gamma.$$

The price efficiency is increasing in trader fraction μ_n, if

$$\Delta(\cdot) = \frac{\partial A(\cdot)}{\partial \mu_n} \cdot B(\cdot) - A(\cdot) \cdot \frac{\partial B(\cdot)}{\partial \mu_n} \tag{53}$$

is positive and decreasing if $\Delta(\cdot) < 0$. Considering that:

$$\frac{\partial A(\cdot)}{\partial \mu_I} = 2 \cdot \frac{\tau_\varepsilon}{\tau_v} \cdot (\alpha_r + \alpha_p) > 0 \;\text{ and }\; \frac{\partial B(\cdot)}{\partial \mu_I} = 0, \tag{54}$$

it is easy to see that PE is increasing in μ_I.

An increasing number of liquidity traders has the following effects on the terms in (52):

$$\frac{\partial A(\cdot)}{\partial \mu_X} = -2 \cdot \frac{\tau_\eta + \rho^2 \cdot \tau_x}{\tau_v} \cdot (\alpha_r + \alpha_p) < 0, \tag{55}$$

$$\frac{\partial B(\cdot)}{\partial \mu_X} = -2 \cdot \left(a_r + \alpha_x \cdot \left(\rho - \frac{\gamma}{\tau_x} \right) \right). \tag{56}$$

Using the definitions of α_r, α_p and α_x and rearranging terms, we find that:

$$\Delta(\cdot) \propto -\gamma \cdot (a_x \cdot (a_r + \alpha_p - \mu_I \cdot \tau_\varepsilon) + a_p \cdot \mu_X \cdot \gamma) - (\gamma \cdot \mu_X - \rho \cdot \mu_L \cdot \tau_x)^2 \cdot \tau_\eta < 0. \quad (57)$$

It follows that PE is decreasing in μ_X. □

Proof of Proposition 4

Following the derivations in the proof of Corollary 3, we note first that an increasing number of limited attention traders has the following effects on the terms in (52):

$$\frac{\partial A(\cdot)}{\partial \mu_L} = -2 \cdot \tau_v^{-1} \cdot (\alpha_r + \alpha_p) \cdot \rho^2 \cdot \tau_x < 0, \quad (58)$$

$$\frac{\partial B(\cdot)}{\partial \mu_X} = -2 \cdot \alpha_x \cdot \rho < 0. \quad (59)$$

Using the definitions of α_r, α_p and α_x and rearranging terms, we find that:

$$\Delta(\cdot) \propto G(\mu_L) = (\gamma \cdot \mu_X - \rho \cdot \mu_L \cdot \tau_x) \cdot a_r \cdot \rho \cdot \tau_x. \quad (60)$$

Evidently, $G(\mu_L)$ is positive as μ_L approaches zero and decreasing in μ_L. Considering the parameter range of $\mu_L \in (0, \bar{\mu}_L)$, where $\bar{\mu}_L = 1 - \mu_I - \mu_X$, there exists a critical value:

$$\mu_L^* = \frac{\gamma \cdot \mu_X}{\rho \cdot \tau_x} \quad (61)$$

that solves the equation in $G(\mu_L^*) = 0$ for μ_L whenever it holds that $G(\bar{\mu}_L) < 0$. Otherwise, if $G(\bar{\mu}_L) > 0$, PE is increasing in μ_L for all $\mu_L \in (0, \bar{\mu}_L)$. □

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